AN

ESSAY

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CAUSES AND PHENOMENA

OF

ANIMAL LIFE.

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ANIMAL LIFE.

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PREFACE.

WHEN conſidered in that extent of which the ſubject is ſuſceptible, Medicine appears to be of the utmoſt conſequence to mankind. But notwithſtanding its importance, it does not ſeem to have been generally ſtudied upon juſt principles: For the fact muſt be acknowledged, that the Healing Art has made a ſlower progreſs towards improvement than almoſt any other branch of Science. Whatever changes and new modifications the doctrines of Medicine may have undergone, medical practice has continued almoſt invariably the ſame, among every ſect of Phyſicians, ſince the days of Hippocrates, till nearly the preſent time.

Since a juſt method of philoſophiſing has been employed, we obſerve a remarkable change to have taken place in every department of Science. Reaſoning from preconceived opinions, and vague hypotheſes, has given place to concluſions founded upon the induction of facts which are either ſelf-obvious, or eſtabliſhed by the ſure teſt of experiment. Guided by this unerring plan, truth has been made to triumph over error,—aſſumed theories, unſupported by facts, are in a great meaſure baniſhed,—and the ſciences, and arts connected with them, are reſpectively arrived at a degree of perfection proportioned to the extent in which ſuch a mode of cultivation has been purſued.

It is however very generally admitted, and it is much to be regretted, that the ſame obſervations cannot with juſtice be applied to Medicine. Why has not the ſame rapid improvement been made in this ſcience, as in other branches of philoſophy? Are the principles of inductive philoſophy inapplicable to Medicine? or have the generality of thoſe who have purſued this ſtudy not availed themſelves of theſe principles? To ſuppoſe that the ſame methods by which truth is diſcriminated from error in other branches of human knowledge, will not apply to the Healing Art, is an evident abſurdity. The operations of Nature in the animal body, whether in the ſtate of health or diſeaſe, are conducted according to fixed laws. It is certainly poſſible, from obſervation and experiment, to aſcertain theſe laws; and from hence to deduce juſt rules for the preſervation of health and cure of diſeaſe. It muſt however be confeſſed, that true philoſophy has not at all times been employed in the proſecution of medical ſtudies.

A few years only have elapſed, ſince an attempt was made by the late Dr John Brown, to apply the principles of modern ſcience, for the cultivation of the Healing Art. It is not intended here to inquire, how far he ſucceeded in the execution of this important taſk. But there are many reaſons to conclude, that this author has been led into conſiderable miſtakes, ariſing from his unlimited ſimplification of cauſe and effect. The fact however is indiſputable, that this new ſyſtem has produced a more remarkable revolution, both in the theoretical and practical departments of this branch of ſcience, than is to be found throughout the whole hiſtory of Medicine. Under all the former doctrines of this Art, and under almoſt every modification of diſeaſe, we find an univerſal ſameneſs in the method of cure. Bleeding, purging, vomiting, and every other mode of evacuation, were indiſcriminately applied, in almoſt every diſeaſe: and even in thoſe caſes in which ſtimulants were employed, or an invigorating plan of cure purſued, theſe were frequently alternated with evacuants, as if certain diſeaſes could not be eradicated, except by the oppoſite means of inducing debility and vigour at the ſame time in the body. Argument is certainly unneceſſary to prove the impropriety

propriety of employing totally diſſimilar powers to combat the ſame diſeaſe.

The practice founded on the new theory in one reſpect reſembles the old, as the ſame method of cure is employed in the far greater number of diſeaſes. The old theoriſts univerſally applied evacuants, and endeavoured to debilitate the ſyſtem by every means. The application of ſtimulants is nearly as univerſal, on the principles of the new theory. According to the aſſertion of its author, this plan of cure ought to be employed in the proportion of ninety-ſeven diſeaſes in the hundred. If this opinion is founded in the nature of things, what havock muſt have been produced by the oppoſite method during the courſe of two thouſand years?

It is however to be feared, that, upon a moderate calculation, both the beneficial and pernicious tendency of either mode of practice is nearly in an equal ratio, in proportion to the time of their reſpective reigns. Mankind hitherto have had a wonderful tendency towards ruſhing into extremes. In no caſe, perhaps, is this fact more fully exemplified, than in the inſtance now before us: For if (as has been aſſerted) the practice under the old theories has had a tendency more frequently to produce death than to cure diſeaſe, it is ſtill perhaps problematical, whether that of more modern date does not, in many inſtances, produce the ſame effect, by employing an oppoſite cauſe. For there is reaſon to believe, that this practice has been carried to the extreme, by thoſe who are acquainted with the principles upon which it is founded, and alſo by thoſe who are guided merely by the univerſal principle of imitation. The method, however, which the author of it adopted, for analizing the Healing Art, has been found of the utmoſt importance for proſecuting diſcoveries in every other branch of Science; and there are good grounds to hope, that by ſtill purſuing the ſame plan with caution, Medicine will progreſſively become a moſt valuable acquiſition to ſociety.

To effect this important purpoſe, ought to be the chief buſineſs of every one who has devoted himſelf to the ſtudy of this ſcience. That much ſtill remains to be done, muſt be granted.

In the following Eſſay, an attempt has been made to ſtate the Cauſes and Phenomena of Animal Life, and the various changes to which the body is liable, by the increaſed or diminiſhed action of thoſe powers which produce life, or of others to the operation of which the animal body may be ſubjected. An accurate knowledge of the cauſes by which animal life is produced and continued, and the various changes to which the body is liable, ſeems to be the baſis upon which only a juſt medical theory and practice can be founded. With what ſucceſs the ſubject has been treated, muſt be left to the determination of the reader. That it is in many reſpects deficient, ariſing from the brevity with which ſo extenſive a ſubject has been treated, and from the imperfect ſtate of our knowledge with regard to the laws of animated nature, the Author is ready to admit; and it may contain errors of which he is not conſcious. If theſe are candidly pointed out, he will cheerfully ſubmit to correction.

The Anatomical Part might, perhaps, in the opinion of ſome readers, have been ſpared. To the Author, however, it ſeemed abſolutely neceſſary for the illuſtration of the ſubject. It is chiefly abſtracted from modern writers, and, in ſome inſtances, almoſt literally.

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THE works of Nature, which may be properly comprehended under the two diviſions of organic and inorganic matter, exhibit an almoſt infinite variety of productions, apparently diſſimilar, yet ſo intimately connected, that each individual ſeems neceſſary to the whole. Under each of theſe forms we obſerve matter ſubjected to perpetual viciſſitude. A series of decompoſitions, and of the formation of new bodies, regularly ſucceed each other. It is the buſineſs of philoſophy to collect the various facts which nature offers to our obſervation, and from a proper arrangement of theſe facts, on the principles of induction, to aſcertain the general laws by which her operations are directed: or in other words, to diſcover thoſe mutual relations which ſubſiſt between the various ſubſtances which form the natural world.

The changes which take place on inorganic matter, the decompoſitions which are effected, the new ſubſtances which are produced, with the forms and qualities which they aſſume, are known to depend upon what are termed the laws of chemical attraction or affinity. Theſe are, in fact, immutable relations ſubſiſting between the various ſpecies of matter. Two or more given bodies will, at all times, if placed in ſimilar circumſtances, exhibit the ſame phenomena. Anomalous caſes of chemical attraction were indeed formerly ſuppoſed to exiſt; but in proportion to the increaſe of our knowledge upon this ſubject, by accurate inveſtigation, theſe ſuppoſed anomalies have diſappeared, and we have obtained the moſt convincing proofs that on inorganic matter nature operates by invariable laws.

The ſame uniformity of operation, we muſt neceſſarily conclude, takes place in the formation of organized ſubſtances, and in the production of the various phenomena which they exhibit. They are not governed by preciſely the ſame, but by equally fixed and invariable laws. The formation of an organized body, whether animal or vegetable, and the production and continuance of that ſpecies of life which it poſſeſſes, with all its phenomena, depend on immutable relations ſubſiſting between various ſpecies of matter.

The deſign in this eſſay is to inſtitute an enquiry concerning the cauſes and phenomena of animal life, particularly in the human ſpecies. The importance of the ſubject will be generally admitted; for the preſervation of health, and the cure of diſeaſes, muſt materially depend upon a juſt knowledge of the cauſes by which the phenomena of life are produced and continued. In the proſecution of this ſubject I ſhall ſtudiouſly avoid hypothetical opinions, and ſhall endeavour to deduce the theory which I hope to eſtabliſh, from indiſputable facts. Where the operations of nature elude our reſearches, we muſt neceſſarily cloſe the enquiry.

The phenomena of life in the human ſpecies, have been attributed to the union of an immaterial ſubſtance to the corporeal frame. It is not intended here, to deny the exiſtence of ſoul or ſpirit, whether purely immaterial, or otherwiſe; but we cannot admit that the animal life in the human ſpecies is produced by the preſence of ſuch a diſtinct ſubſtance, becauſe we obſerve the ſame ſpecies of life, the ſame animal functions, poſſeſſed by the inferior orders of the animal kingdom. Something analogous to animal life is alſo ſufficiently obvious in the vegetable kingdom, though in a lower degree; and no one, it is preſumed, will be inclined to ſuppoſe the exiſtence of ſpirit in vegetables. The notion of an animal ſoul, by which all the functions of body are directed, is mere hypotheſis, unſupported by a ſingle fact. The *archæus* of Van Helmont, and the *vis medicatrix naturæ* of later phyſiologiſts, whether intended to expreſs ſubſtances diſtinct from body, or only certain powers poſſeſſed by organized matter, ſeem too much founded upon fancy to deſerve a particular conſideration.

In aſcertaining the cauſes of animal life, it is neceſſary firſt to point out the criteria by which we diſtinguiſh animate from inanimate matter. Theſe are, ſenſation, perception, and motion. By ſenſation, we mean diſtinct feelings of pain or pleaſure, produced by the operation of various agents. By perception, we denote the conſciouſneſs of ſuch feelings. The term motion it is unneceſſary to explain. Theſe properties we perceive exiſting in a greater or leſſer degree in all animals. In man, and the other nobler animals, they exiſt in the higheſt degree. In the inferior orders, we obſerve the powers of life more circumſcribed; yet, in as far as we perceive,

ceive, that they have organs ſimilar to our own, and that when acted upon by certain powers, the ſame phenomena are produced in them as in ourſelves, we muſt infer that they poſſeſs the ſame properties.

The exiſtence of theſe properties, ſenſation, perception, and motion, are the ſole criteria of life, and theſe are produced by the action of certain powers or agents. The rays of light, reflected on the retina from any ſubſtance, produce the ſenſation called ſight: the undulating motion of the air, ariſing from the vibrations of a ſonorous body, produces the ſenſation of ſound, or hearing: the contact of another ſubſtance conſtitutes feeling: and the operation of the mental function, or of any chemical or mechanical ſtimulus, on muſcular fibre, produces motion. The poſſeſſion of theſe properties diſtinguiſhes living from dead matter. Now we cannot account for theſe properties upon any mechanical principles; nor can the moſt accurate inveſtigation of the ſtructure or conſtituents of the animal body, diſcover the cauſe of that capacity which we obſerve in organized matter, of being thus acted upon by the different powers which excite motion or produce ſenſation. The anatomiſt may trace, and ſhow, to a certain degree, the diſtribution of particular nerves, blood-veſſels, and muſcular fibres: the chemiſt may exhibit their conſtituents, by the laſt reſult of analyſis: but however important their labours are in other reſpects, hitherto they have not thrown any light on that peculiar capacity, which we obſerve in animal bodies, of being acted upon; the conſequence of which action is the production of the phenomena of life. We are reduced therefore to the neceſſity of concluding, that this capacity depends ſimply upon a peculiar organization: and that, by ſeveral modifications of that organization, the body is rendered, in its various parts, ſuſceptible of the action of different powers, by which all the ſenſations and motions are excited. The moſt diſtinct notion that we can obtain of life, perhaps, is, that it is a ſtate produced in organized bodies, by the operation of certain agents. Mere organic ſtructure is not ſufficient to account for the phenomena of life: it is neceſſary that this organized matter ſhould be acted upon by powers ſuited to its nature and ſtructure, by which its ſenſations are awakened, and every part is excited to action. There is an immutable relation ſubſiſting between the different powers or agents, and the organized bodies upon which they operate, depending on the peculiar nature of their organization. Theſe powers act not, or at leaſt act in a very different manner, upon inorganized matter. Their operation continues invariably the ſame upon organized ſubſtances while their ſtructure remains unimpaired: but if the organization becomes deranged to a certain extent, theſe powers are no longer capable of producing the phenomena of life; and their action is preciſely the ſame as upon inorganic matter.

If it is indeed true that we cannot aſcertain the cauſe why organic matter is ſuſceptible of the action of certain agents; if we can only perceive the effects of theſe agents upon organized ſubſtances, but in moſt inſtances cannot diſcover the mode of their operation; and if we can only eſtimate their beneficial or injurious powers, by the effects which follow their operation; it muſt remain as an ultimate fact, that the ſuſceptibility which we obſerve in the animal body to be excited by certain powers, depends upon its peculiar organization.

The capacity which the body poſſeſſes, of being excited to action by ſtimuli, has been termed the principle of excitability. The author who firſt employed the term aſſumed it as an ultimate fact: and ſo far was he from endeavouring to explain the cauſe of that excitability, that he even deprecated the attempt *. This however has not deterred others from endeavouring to aſcertain the cauſe or nature of that principle. The moſt remarkable attempt of this kind, is that lately made by Dr. Girtanner †. It is generally known, that

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* Vide Element. Med. Brun. vol. i. p. 6.

† Vide Journal de Phyſique.

the leading principles of this gentleman's theory are borrowed from the writings of the late Dr Brown, although he has not acknowledged the ſource from which they were derived. To the theory of Brown, ſlightly modified, he has endeavoured to apply the diſcoveries of modern chemiſtry. By a variety of experiments, he has attempted to prove, that the excitability of the animal ſyſtem, which he chooſes to ſtyle irritability, is entirely owing to the preſence of oxygene: or in other words, he aſſerts that oxygene is the principle of irritability. By the accumulation or exhauſtion of this ſubſtance, he endeavours to explain the mode in which the various agents act upon the body. He has indeed almoſt ſolely applied his reaſoning to the muſcular fibre, which, in his opinion, becomes more or leſs irritable, in proportion to the quantity of oxygene contained in the ſyſtem: in ſhort, all the phenomena of life appear to depend upon the preſence of this ſubſtance. Oxygene, then, with Girtanner, ſupplies the place of the vital principle, the *archæus*, the animal ſoul, or the *vis medicatrix naturæ* of former theoriſts. The new theory has indeed this advantage over the old, that, inſtead of vague and unmeaning terms, we are preſented with a ſubſtance with which we are in ſome degree acquainted, and which really exiſts in organized matter; ſo that the principle of life is here attributed to ſomething.

We may readily admit that many of Dr Girtanner's experiments upon this ſubject are ingenious, and his reaſoning frequently plauſible; yet we cannot adopt his opinion: nor, in offering a ſufficient refutation of it, will it be neceſſary to enter into a minute examination of his experiments, or the deductions which he has drawn from them. A few general obſervations will ſufficiently evince that his theory is not tenable. I obſerve therefore, firſt, that oxygene is indeed known to be a conſtituent of animal bodies; and it may perhaps be received into the ſyſtem in two ways: by reſpiration, and in the aliment. Before it is received into the body, and aſſimilated to the ſyſtem, in whatever form it is preſented, it cannot be the principle of irritability, but is one of the agents which acts upon the excitable or irritable principle. After it is aſſimilated to the body, it forms only one of the conſtituents of which the organic matter conſiſts; and it is undoubtedly the whole organic matter which is the ſubject of excitation, not merely one of its conſtituents.

But, ſecondly, if it is alledged that life, and conſequently the capacity of being excited, is taken away from organized ſubſtances, by the with-holding the neceſſary ſupply of oxygene, it muſt be remembered, that the ſame effect is produced by with-holding any other of thoſe agents which produce and ſupport the phenomena of life; ſuch as heat, aliment, &c. We might therefore as well ſuppoſe that the caloric, or matter of heat, the carbone, hydrogene, or azote, which we receive in our aliment; I ſay, we may as well ſuppoſe that one or more of theſe is the excitable principle, as oxygene.

And laſtly, were oxygene indeed the vital principle, the fact is not proved by thoſe experiments which Dr Girtanner imagines the moſt completely ſatisfactory, or by the reaſonings which he ſeems to think abſolutely deciſive. He has, with ſome propriety, attempted to form an arrangement of the different agents which act upon the body: he has divided them into three claſſes. The firſt he ſuppoſes to have the ſame degree of affinity to oxygene, or the irritable principle, as the organized fibre itſelf: theſe ſubſtances he therefore imagines produce no effect upon the fibre. The ſecond claſs are thoſe which have a leſs degree of affinity with oxygene than the fibre has; and which will therefore part with oxygene, and ſurcharge the fibre with it: theſe he ſuppoſes produce an accumulation of the irritable principle; and the ſubſtances which effect this, he calls negative ſtimuli. The third claſs contains thoſe ſubſtances which have a greater affinity to oxygene than the fibre itſelf has, and which will conſequently deprive it of oxygene, and produce the ſtate of exhauſtion: theſe ſubſtances he calls poſitive ſtimuli. To this arrangement ſeveral valid objections may be made; but I ſhall not enter upon the ſubject at preſent. What I am here principally concerned with, is the application which he makes of his experiments and reaſonings on the two laſt claſſes, the negative and poſitive ſtimuli, in ſupport of the opinion that oxygene is the irritable principle. He aſſerts that the poſitive ſtimuli, the moſt powerful of which he ſtates to be alcohol, ſulphuric æther, opium, and the oleum lauro-ceraſi, deprive the fibre of oxygene, by actually entering into combination with it; and he ſupports this opinion by chemical facts, which are in themſelves no doubt perfectly juſt, viz. that theſe ſubſtances are all highly combuſtible; i. e. that they have a great affinity with oxygene. But from theſe facts he draws a concluſion which is by no means admiſſible, viz. that they deprive the organized fibre of its irritability, by entering into combination with the oxygene it contains. When animal life is deſtroyed by any of the poſitive ſtimuli, he alledges, that the irritability of the moving fibre, in every part of the ſyſtem, is inſtantaneouſly taken away. But allowing this to be the fact, it is impoſſible, at leaſt in many inſtances, that it ſhould have been effected by the actual combination of the poſitive ſtimulus, or combuſtible ſubſtance, with the whole, or the major part of the oxygene contained in the body. A ſingle drop of the oleum lauro-ceraſi received into the ſtomach, produces immediate death. But can the moſt credulous believe, either that the drop of oil was inſtantaneouſly changed into ſo minute a ſtate of diviſion, as to be diſtributed through every part of the ſyſtem; or if it had, that it could attract and be united with the whole oxygene of the body? Will chemical experiment prove this? Quite the reverſe. Let us ſubject ſuch a portion of the oil to combuſtion, let us oxygenate it in the higheſt poſſible degree, and we ſhall find that the quantity of oxygene with which it will unite, will bear a very inconſiderable proportion to the quantity contained in the body of an animal, the life of which may be deſtroyed by a ſimilar drop of the oil.

Upon the other hand, he ſuppoſes that the negative ſtimuli, as he terms them, communicate oxygene to the muſcular fibre: among theſe he reckons many of the acids and oxydes of metals. The moſt powerful are conſequently the oxygenated acids, and thoſe metallic oxydes which moſt readily part with their oxygene. Thus the oxygenated muriatic acid; the oxygenated metallic ſalts, as the oxygenated muriate of mercury; and the oxydes of arſenic, mercury, and ſilver, he ſuppoſes, produce injurious effects in proportion to the quantity of oxygene they contain, and the facility with which they part with it. By communicating their oxygene, he ſuppoſes that the muſcular fibre becomes hyper-oxygenated. But here, as in the former caſe of the poſitive ſtimuli, the cauſe is by no means adequate to the ſuppoſed effect. It is indeed true, that mercurial and ſilver erodents deſtroy the organization, of the part to which they are immediately applied, by their oxygene uniting with one or more of the conſtituents of the animal ſubſtance. But it cannot be admitted, that a few grains of the white oxyde of arſenic, or the oxygenated muriate of mercury, can poſſibly contain ſuch a quantity of oxygene as will induce death by a hyper-oxygenation of the ſyſtem. Dr Girtanner's opinion upon this ſubject is perhaps ſufficiently refuted by a ſingle fact, viz. that, according to his own ſuppoſition, we receive into the body, by a few inſpirations, a greater quantity of oxygene than can be contained in the ſmall portions of the mineral poiſons we have mentioned which are ſufficient to produce death. Why then is not the ſyſtem hyper-oxygenated by reſpiration, as well as by theſe deleterious ſubſtances? It is in vain to reply, that the oxygene received by reſpiration, is only in ſuch proportion as is immediately neceſſary to oxygenate the ſyſtem. For the queſtion here depends alone upon the quantity of oxygene received into the ſyſtem in a given period: and it is evident that the quantity contained in ſuch a portion of the oxyde of arſenic as will cauſe death, is exceedingly trifling. At any rate, a few inſpirations of pure oxygenous gas ought, upon this principle, to be equally deleterious with a doſe of arſenic.

By the term irritable principle, as we have already obſerved, Doctor Girtanner means that capacity which organized matter poſſeſſes of being acted upon by various agents. The obſervations which we have here offered, it is preſumed, ſufficiently prove, that in his attempt to detect the principle of irritability, he has not been more ſucceſsful than his predeceſſors.

That the excitability of the body, and its various parts, depends upon a peculiar organization, ſeems perfectly clear; and perhaps a further knowledge of the ſubject is beyond the power of human reſearch: yet we would not wiſh to be underſtood as precluding future inquiry. But we may be allowed to add, that forming uncertain

certain hypotheſes upon this, or any other ſubject, cannot advance the intereſt of ſcience.

Quitting then the vague opinions which have been held concerning the principle of animal life, we ſhall endeavour, by induction from the facts which paſs under our obſervation, to aſcertain the cauſe or cauſes which produce the phenomena of life, and maintain that life in the healthful ſtate.

In the proſecution of this ſubject, we ſhall firſt take a brief view of the ſtructure of the animal body, chiefly with the deſign of ſhowing that a ſimilar organization, under various modifications, takes place in every part.

Secondly, we ſhall endeavour to ſhow, that by the union of the various parts of the animal body, a complete and indiviſible whole is formed, ſo that any agent which operates upon a particular part, muſt in a greater or leſſer degree affect the whole.

Thirdly,

Thirdly, we ſhall offer ſome general obſervations on the nature of excitability, or that principle, which appears to exiſt in every part of the body; and by which it is rendered ſuſceptible of the action of various agents.

And laſtly, we ſhall take a brief view of thoſe agents, by the operation of which, upon organized matter, the phenomena of life are produced and continued.

In the courſe of our obſervations upon this ſubject, we muſt neceſſarily notice ſome of the cauſes that are injurious to health; and which, operating to a certain degree, deſtroy life. The agents which are neceſſary to produce the phenomena of life, and to preſerve the healthful ſtate, are naturally divided into two kinds; the external and internal. It is to this point alone, the production and continuance of life in the healthful ſtate, that I mean to confine myſelf in this Eſſay: but it may be obſerved, that in taking an extenſive view of this ſubject, it would be proper to conſider not only thoſe which produce life and preſerve health, but thoſe which are directly injurious to the ſyſtem; and alſo ſuch as may be employed to counteract the effects of the injurious agents. This ſubject is exceedingly complicated; and it is difficult to form any accurate arrangement. The difficulty chiefly ariſes from the very different effects which are produced in the animal ſyſtem, by the action of various proportions of almoſt any of the agents, which are capable of operating upon the body. Thus thoſe agents, the operation of which is abſolutely eſſential to life and health, will, when acting with too great force, induce diſeaſe, and even deſtroy life. The action of the ſame powers alſo, may be ſo modified, as to counteract the injurious effects produced by their own operation, or that of other agents. In like manner, ſome of thoſe agents, the action of which is not eſſential to life, and which are able utterly to deſtroy the organization of the body, may, when employed in certain proportions, reſtore the ſyſtem to the ſtate of health. I ſhall attempt, however, to form an arrangement of theſe powers, although, from the intricate nature of the ſubject, I muſt neceſſarily expect that it may be liable to exceptions.

We may firſt mention thoſe agents which, when acting in juſt proportion, produce the phenomena of life, and the healthful ſtate. In treating on this claſs, it is neceſſary to conſider the injurious effects which are produced by the ſame powers upon the organization, when acting in an improper proportion. We have obſerved, that they are naturally divided into the external and internal agents. The external agents, the action of which are eſſentially requiſite to the production and continuance of the phenomena of life, are heat, air, and aliment. To theſe we may add, light, ſound, and the qualities which we perceive in certain bodies, of odour and ſapidity; which, though perhaps not abſolutely eſſential to animal life, yet produce very powerful effects upon the ſyſtem. Light is eſſential to the healthful ſtate of almoſt every individual of the vegetable kingdom; and is perhaps, in the ſame view, requiſite to the animal œconomy. Sound alſo produces very powerful effects upon the body. It is one of the moſt important agents in the intercourſe of mankind. It is the chief mode of communication between the individuals of all the nobler ſpecies of the animal kingdom, and alſo affords a degree of intercourſe between individuals of different ſpecies. The influence of ſound upon the mental powers, produces in many caſes the moſt important effects upon the body. It is equally obvious, that the qualities of odour and ſapidity, in certain ſubſtances, are capable of exciting the animal ſyſtem in a high degree. The whole of theſe, therefore, may be properly conſidered as belonging to the diviſion of external agents.

The internal agents, the operation of which are eſſential to the production and continuance of the phenomena of life, are, the blood, the fluids ſecreted from the blood, the intellectual functions, and muſcular motion: to theſe we may add the ſexual intercourſe. This, though not eſſential to life, is a power which produces very conſiderable effects on the organization of almoſt every individual of the ſpecies. When confined within proper bounds, it is perhaps rather conducive to health, than injurious to the ſyſtem; and ſhould therefore be included in this diviſion.

Several of theſe agents are intimately connected with peculiar functions of the body. It is neceſſary therefore, in treating upon the agents, to conſider thoſe functions in which their action is peculiarly evident. Thus, when treating upon air, we muſt neceſſarily conſider the reſpiratory function; and the conſideration of aliment ſhould be combined with the digeſtive proceſs.

The whole of this claſs, whether external or internal agents, evidently excite action in the ſyſtem at large, or more particularly in certain parts: it is plain therefore, that they poſſeſs ſtimulant powers; and we ſhall therefore appropriate to them the terms of the natural or healthful agents, or natural ſtimuli.

A ſecond claſs of agents are ſuch as are capable of operating, in various degrees, upon the body; the action of which, in any proportion, generally produces injurious effects, inducing the morbid ſtate. The powers included in this claſs, operate in various degrees, according to their nature, the degree of their application, and the ſtate of the body upon which they act. The mode of operation in different ſubſtances of this claſs, alſo vary exceedingly: ſome of them excite action in the ſyſtem, whilſt others inſtantaneouſly deſtroy life. We muſt conclude, therefore, that their qualities, and mode of operation, materially differ. In this claſs we comprehend the various ſpecies of contagion, as of the ſmall pox, meaſles, chincough, typhus, the marſh miaſmata, the venereal virus, the contagion of the plague, the azotic gas, and the various ſpecies of poiſons, whether animal, vegetable, or mineral. It muſt be admitted, that very material varieties are obſerved in the operation of different powers in this liſt. The contagion of the ſmall pox, for example, excites an increaſed action of the ſyſtem; whilſt that of the marſh miaſmata, or typhus, directly induces an univerſal and direct debility. No two powers can operate in a more oppoſite manner; nor can their action be accounted for, upon the ſame principle. It muſt be regretted, that the diſpute relative to the ſtimulant and ſedative effects of many ſubſtances, has degenerated into a mere logomachy, in which both parties were perfectly agreed as to facts, although they choſe to diſpute about words. Many of the ſubſtances which have been included in the liſt of ſedantia, may be eaſily proved to be ſtimulants. But, on the contrary, it muſt be acknowledged, that the concluſion, that there is no direct ſedative in nature, was too haſtily drawn. We ſhall have an opportunity of illuſtrating this ſubject in ſome of the ſubſequent pages. As theſe agents differ in their qualities and mode of operation, we may apply to them the general term of morbid agents: or morbid ſtimuli and ſedatives.

A third claſs of ſubſtances are thoſe which are not natural or healthful agents, but which, when employed in juſt proportion, are able to counteract the effects of the morbid agents. Many of theſe may indeed be included in the liſt of morbid agents; and the whole of them, when acting in an undue proportion, will alſo produce injurious effects on the body. This liſt contains the whole of thoſe ſubſtances, which can be employed as curative powers in the various diſeaſes to which mankind are ſubjected. A conſiderable proportion of this claſs are undoubtedly ſtimulant: and probably the greater part are of the ſame nature. As diſtinctive appellations, we ſhall apply to them the terms, artificial agents, or artificial ſtimuli, and ſedatives.

We proceed to take a curſory view of the ſtructure of the animal body, chiefly with the deſign of ſhowing, that a ſimilar organization, under various modifications, takes place in every part.

In the human ſyſtem we obſerve a variety of parts formed of matter apparently under very different kinds of modification. Theſe, however, conſtitute a whole, the different parts of which are ſuſceptible of various degrees of impreſſions from powers, to the action of which they are ſubjected. This entirely ariſes from the mode of their organization. The bones, from the nature of their organization, are perhaps leſs ſuſceptible of the action of powers applied to them, than any other part of the ſyſtem; they appear deſigned to form the baſis of the body; they ſupport the ſoft parts; they defend and contain the more delicate and noble organs. Though liable to diſeaſe, they are not ſubject to injury like the other parts; and even after death, that rapid and ſpontaneous decompoſition, does not take place in them, which we perceive in the reſt of the ſyſtem. They may be expoſed for ages, without loſing their original form; and they ſeem to bear a conſiderable analogy to inorganized matter.

Anatomical reſearch, however, fully proves, that bone is as truly organized matter, as any other part of the body. This indeed is a concluſion which we might have drawn *a priori*, from the conſideration, that inorganized matter could not poſſibly form a part of an animated ſyſtem. The anatomiſt proves the truth of the aſſertion. He ſhows that the bones are ſupplied with blood veſſels, as well as the fleſhy parts. He exhibits their ſtructure, and points out their periods of growth and decay, which can only be effected by the action of depoſiting and abſorbing veſſels; and in ſhort, fully proves, that they are as truly organized matter as the reſt of the body. But their organization is ſo conſtituted, as to be exactly fitted for the purpoſe they are deſtined to ſerve.

In fact, we obſerve, that bones are formed of a ſyſtem of veſſels, in the interſtices of which, a ſeemingly earthy matter, mixed with mucus, is depoſited. This earthy matter, which gives hardneſs and ſtrength to the bones, is in reality inorganized and dead matter,—a true phoſphate of lime, liable to no alteration when ſeparated from the body, excepting by the operation of the laws of chemical attraction.

The bones are alſo ſupplied with nerves. They may be obſerved, in ſmall threads, entering into the ſubſtance of the bones. Small nerves may alſo be ſeen entering into each bone, along with its nutritious veſſels; and in ſome caſes we obſerve them paſſing through large holes in bones, as the nerves which go into the jaws to ſupply the teeth. But, notwithſtanding that anatomiſts can demonſtrate the exiſtence of nerves in the bones, yet the fact has been doubted, becauſe the bones ſeem inſenſible to pain. It is true, the perioſteum may be ſcraped from a bone,—a bone may be cut through, as in amputation, or in the operation of trepanning,—or cauſtics may be applied to bone; and the patient, in all theſe caſes, ſcarcely feels any pain. It muſt, however, be admitted, that bone, even in the healthy ſtate, poſſeſſes a low degree of ſenſibility. The actual cautery, which, in former periods, was much employed by ſurgeons, is known to produce a ſenſation in the bone, though ſaid to be rather pleaſant than painful. This, however, is a ſufficient proof, that the bones are not abſolutely incapable of feeling. But the ſenſibility of bone is ſufficiently obvious in the diſeaſed ſtate: Injuries of various kinds will excite inflammation in it, as well as in the ſoft parts; and we obſerve the ſame phenomena produced in both. An increaſed determination of blood to the part ſwelling, a ſpongy looſeneſs of texture, ſuppuration, and ulcer, take place in bone, in a manner preciſely ſimilar to what we obſerve in the ſoft parts. And as in the latter the organization is deſtroyed, ſo alſo in the former we obſerve the bone eroded, and diſcharged by ulceration. During the progreſs of ſuch a diſeaſe, the ſenſibility of the bone is aſtoniſhingly increaſed. Thus in the parts which poſſeſs the moſt acute feeling, we obſerve the ſenſibility increaſed by diſeaſe. In like manner the bones, ligaments, burſæ, and other parts, in which, during health, the feeling is ſcarcely perceptible, become, by diſeaſe, extremely ſenſible, ſo as to give the moſt exquiſite pain in many caſes, ſuperior to what is experienced in a ſimilar diſeaſe of the ſoft parts.

In every view that we can take of the ſubject, bone appears to be as perfectly organized matter, as any other part of the body. It receives its ſhare of the ſanguiferous and abſorbent veſſels; it is ſupplied with nerves, and by all of them is immediately and intimately connected with the ſyſtem at large. It is produced, by the animalizing proceſs; it is liable to diſeaſe and death; it is ſuſceptible of impreſſions from ſtimuli; and by their operation is excited to action.

Thus the bones are conſtructed upon a plan admirably calculated for the purpoſe they are intended to ſerve in the body. In order to give them hardneſs and inflexibility, they are chiefly compoſed of an earthy ſalt. This ſalt is depoſited by circulating veſſels, which enter their ſubſtance; and when it has remained for a certain period, it is abſorbed and carried out of the ſyſtem by a ſet of veſſels deſtined for that purpoſe. Thus a continual depoſition and abſorption is going on in the bones, as well as in any other part of the body. The nerves with which bone is ſupplied, are doubtleſs intended to ſupply the veſſels which are ramified through its ſubſtance; as we cannot ſuppoſe that they have any uſe with reſpect to the inorganic earthy ſalt, of which bone is chiefly formed. Upon the whole, then, it appears, that bone muſt be leſs capable of ſenſation, and leſs liable to be acted upon, than perhaps any other part of the body, as it is only the veſſels and nerves which belong to it that are capable of ſenſation.

Cartilage poſſeſſes a degree of organization ſomewhat inferior to that of bone. This ſubſtance is interpoſed between bones, particularly at the joints, with the view, it would ſeem, of abating friction, and preventing thoſe injuries which might be expected from the colliſion of the harder bony matter. Hence they are ſo conſtituted as to poſſeſs a degree of elaſticity, by which they yield to the weight of the body, and are reſtored to their original ſize when that weight is removed.

Cartilage was at one time ſuppoſed to be a mere concrete, having little or no connection with the other parts of the ſyſtem, except by mechanical coheſion. But, in the original formation of bone, it appears that cartilage is organized matter, and as truly connected with the ſyſtem as any other part of the animal. Thus we obſerve, that the bones are terminated at their articulations by a thin cartilage; and the perioſteum is extended over the ſurface of the cartilage. The circulation in cartilage is indeed not very active, but ſufficient to preſerve it in the living ſtate. Had the powers of life been conſiderable in cartilaginous matter, had its feelings been acute, it muſt have produced very conſiderable inconveniencies to the animal: it would have been liable to frequent inflammation, and other diſorders. But, having received a peculiar mode of organization, in which the feeling is obſcure, and the excitability dull, it is admirably fitted to perform all the motions of the body, and is ſubjected to the friction of the joints, without being liable to injury.

The cellular ſubſtance, like bone and cartilage, poſſeſſes a low degree of ſenſation, and its excitability is obſcure. This matter, under various modifications, is employed to unite, cover, and defend the other parts of the ſyſtem. In all the forms in which it ſubſiſts in the body, it poſſeſſes little ſenſibility; and may, when compared with the muſcular and nervous ſolids, be almoſt conſidered as inanimate matter: that is, when in the healthy ſtate, like bone and cartilage, its excitability is in a very low degree. Both mechanical and chemical ſtimulants, when applied to it, give but little ſenſe of pain.

Firſt, The cellular ſubſtance is extended over the whole body, and interpoſed between all the parts. Formed into an infinite multitude of cells, which contain fat and a thinner fluid, it is happily conſtructed to allow the parts to glide and move eaſily. It penetrates into the muſcles, and keeps their fibres at a proper diſtance, ſo that the action of each may be duly exerted. It appears alſo to ſupport and lubricate the muſcular fibre, inſomuch that the ſtrength of the ſyſtem in health, and its weakneſs in diſeaſe, have been ſuppoſed in ſome degree to depend upon the proper or improper ſtate of the cellular matter. It has generally been imagined, that the thinner fluid contained in the cells is deſigned to render the play of the fibres eaſy and free; and that the fat is intended to ſupport the fibres in their action, to lubricate them, and to give a plumpneſs to the body. It has alſo been ſuggeſted, that it may be reabſorbed for various uſes in the ſyſtem. It is probable, however, that the ſebaceous matter, like the phoſphate of lime in the bones, can only be applied to its proper uſes in the ſyſtem for a certain period. By degrees it becomes unfit for the purpoſes of the animal economy. It is ſecreted and depoſited in the cells, and, when reabſorbed, is probably, with other excrementitious matter, thrown out of the ſyſtem.

Secondly, A modification of the cellular ſubſtance is employed as a covering to the bones. The perioſteum, as it is called, appears to be a condenſation of the cellular ſubſtance applied in ſucceſſive layers, ſo as to produce a thick membrane, which conveys the blood-veſſels, &c. to the bones.

Thirdly, The tendons of the muſcles are produced by a mere continuation of the perioſteum, from which they are evidently derived, and not from the muſcles, as the old anatomiſts imagined.

Fourthly, The tendinous matter ſomewhat differently modified, ſo as to form a thin membranous ſheet, is employed to cover the muſcles forming the vaginæ or faſciæ of the muſcles. The cellular ſubſtance which lies under the faſcia, and which immediately ſurrounds the muſcle, appears to be only more looſely attached laminæ of the faſcia. It is from the faſcia that the cellular matter is derived which penetrates into the muſcles.

Fifthly, The perioſteum, formed into a thicker membrane, and ſtrengthened by the adheſion of ſurrounding parts, is employed for the capſules of the joints.

Sixthly, The burſæ mucoſæ derive their origin from the ſame ſubſtance. The burſæ are formed in thoſe parts where a tendon plays over a bone. The upper ſurface of the burſa is formed by the tendon itſelf;—the lower ſurface of the ſame burſa is produced from the perioſteum of the bone; — and the ſides of the burſa are formed by the common cellular ſubſtance. The burſæ mucoſæ and capſular ligaments do not materially differ in their nature. They contain preciſely the ſame kind of liquor, and they frequently communicate with each other *.

Thus, under a variety of modifications, the cellular ſubſtance is applied to many uſeful purpoſes in the ſyſtem. It joins the bones to each other,—it unites the muſcles to the bones,—it gives ſecurity and firmneſs to their motions,—by the fluids which it contains, it lubricates the joints and muſcular fibre,—and it is further employed to give a plumpneſs and agreeable ſhape to the limbs.—For all theſe purpoſes it appears to be peculiarly fitted, by poſſeſſing a degree of ſenſibility much inferior to that of the more important parts of the ſyſtem.

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* Vid. Mr John Bell's Anatomy of the Bones, Muſcles, and Joints.

Under all the modifications which we have now mentioned, cellular ſubſtance appears to have few blood-veſſels, and no nerves; at leaſt no nerves are viſible. But we muſt conclude, that the few blood-veſſels which convey nutrition to the cellular ſubſtance muſt be accompanied with nerves, however minute. And the feeling which can, by diſeaſe, be awakened in theſe parts, muſt lead us to infer, that they are in ſome degree ſupplied with nerves; as we cannot conceive that ſenſation can be produced, except by the agency of nerve. The paucity, however, of blood-veſſels and nerves in the cellular ſubſtance, ſufficiently evinces, that theſe parts can be little ſuſceptible of the action of ſtimuli; and the fact which we thus diſcover from the ſtructure of the parts, is ſtrikingly evidenced by experiment. Under all its different modifications, cellular ſubſtance in the healthy ſtate appears to be inſenſible to the action, both of mechanical and chemical ſtimulants. The tendons of animals have been cut and pierced,—they have been pinched and torn, —the actual cautery, as well as the chemical, have been applied, without inducing the leaſt indication of pain in the animal ſubjected to the experiment. The moſt violent chemical ſtimuli have been applied to the various parts of a joint, without producing any appearance of an uneaſy ſenſation. In like manner, in chirurgical operations, the various modifications of the cellular ſubſtance may be operated upon without producing any degree of pain to the patient. Nay, it appears that little pain is induced by the accidental laceration of the ligaments and tendons. We cannot indeed ſay that theſe parts are entirely without feeling. Their ſenſibility is indeed dull. They receive the impreſſions of ſtimuli very ſlowly; but when, by diſeaſe, the organization of the part is deranged, the feeling is aſtoniſhingly increaſed, and the patient ſuffers a more acute pain than what we obſerve in almoſt any other part of the ſyſtem. One thing, however, is obvious, the organ of ſenſation in theſe parts muſt be preciſely the ſame as in the reſt of the body. It is only to the nerves that we can aſcribe this quality. They may, in the cellular ſubſtance, during the ſtate of health, be peculiarly ſheathed and defended from impreſſions to which they become expoſed when the organization of the part is injured by diſeaſe.

In the muſcular and nervous fibre, we perceive the powers of life exerted with much greater activity than in thoſe parts which we have hitherto noticed ; or, more properly ſpeaking, muſcular and nervous fibre are much more ſuſceptible of the action of ſtimuli, than bone, cartilage, or cellular ſubſtance. It is by impreſſions upon theſe, by the operation of various agents, that every power of the body is awakened and called into action.

The muſcular and nervous ſyſtems appear to be ſo intimately connected, that ſome phyſiologiſts have imagined that muſcular fibre is a mere continuation of the nervous matter. Anatomy inſtantly refutes this opinion : The nerves enter into the muſcles in every poſſible direction; and we may trace their branches and ramifications perfectly diſtinct from the muſcular fibre. We cannot indeed trace their courſe to their termination, becauſe they become deprived of their external coats, mere medullary matter remains, and diſappears among the muſcular fibres. It is perhaps ſtill more clear, that muſcular fibre is not a continuation of nerve, becauſe muſcles in the limbs of animals do not diminiſh in magnitude, although the nerves entering theſe muſcles have been cut through for a conſiderable period. Yet there certainly exiſts an intimate and univerſal connection between the muſcular fibre and the nerves; becauſe neither the one nor the other can be acted upon by any ſtimulus, without the whole body being affected in a greater or leſſer degree, according to the nature of the part, and the powers of the ſtimulus applied. We find then that both muſcular and nervous fibre are ſuſceptible of impreſſions from ſtimuli: But it is alſo true, that the effects produced on theſe two ſubſtances in ſome reſpects vary. Theſe differences will appear from the ſhort account which we ſhall here give, beginning with muſcular fibre.

Every diſtinct muſcle is formed of a congeries of longitudinal fibres, which are connected together, as we have already hinted, by the cellular ſubſtance. They are extended from bone to bone, and from part to part, ſo as to form an almoſt univerſal covering to the bones, and are at the ſame time the inſtruments by which all the motions of the bones are performed. Each congeries of muſcular fibre appears diſtinct from the reſt, being terminated at its origin and inſertion by its proper tendons, which, as we have ſaid, are a modification of the cellular ſubſtance. Thoſe muſcles which are not inſerted into any of the bones, as the ſphincters and muſcular membranes of the viſcera and veſſels, have commonly no tendons. Thoſe, again, the origin and inſertion of which are on different bones, and in the more moveable extremities, are generally ſupplied with long tendons, which paſs round the joints and heads of the bones to be inſerted in the more moveable part. But however diſtinct the different muſcles appear, there is an univerſal connection, which depends upon the univerſal diſtribution of the nerves; one or more of which enter into each muſcle, and thus form an indiviſible whole.

The muſcles are alſo abundantly ſupplied with arteries and veins, which enter within the cellular coat that ſurrounds the muſcular fibres, and running in company with each other, are ſubdivided, and form a kind of reticular work. From the ſmaller of theſe veſſels a vapour and ſebaceous matter are ſecreted into the cellular ſubſtance, and which are again abſorbed by lymphatics, the preſence of which is alſo perfectly obvious, both on the ſurface and in the ſubſtance of the muſcles. The ultimate fibres of the muſcles appear to be ſmall ſoft threads: When ſubjected to the microſcope, they exhibit a kind of wave or zigzag appearance. This form has been attributed to the impreſſions made by the veſſels, cellular ſubſtance, and nerves upon the fibre. The learned Profeſſor of Anatomy in this Univerſity has however demonſtrated a ſimilar appearance in the tendons and nerves; and he is of opinion, that theſe undulations are a kind of folds or joints, which ſerve to accommodate the parts to the different ſtates of flexion and extenſion. In proof of this, he obſerves, that theſe appearances are only preſent when the parts are in a relaxed ſtate, and that they entirely loſe it when much ſtretched.

Many opinions have been entertained with reſpect to the ſtructure of the muſcular fibre: It has been ſuppoſed that they are ſolid; again it is ſaid that they are hollow, being formed of a ſeries of veſſels or rhomboidal chains communicating with each other; and laſtly, it has been alledged, that they are full of a kind of down or woolly ſubſtance. The fact cannot be determined by the eye or the microſcope,

croſcope, and therefore I conceive it not worth while to engage in the diſpute. Indeed, as far as we can diſcover, the muſcular fibre, when waſhed from the blood contained in the veſſels which accompany it, appears a white ſoft ſolid.

Theſe delicate fibres, formed into bundles of different magnitudes, and variouſly diſpoſed,—ſupplied with blood-veſſels and abſorbents,—joined together, and ſupported by cellular ſubſtance,—and united together, ſo as to form one grand ſyſtem, by the diſtribution of nerves, are deſtined to perform the moſt important offices in the body. Every motion is produced by their operation. They poſſeſs a kind of contractile power, by which they are fitted to propel the blood from the heart, and direct its courſe through all the numberleſs channels in which it flows throughout the body. They produce the action of the lymphatics, by which abſorption is carried on;—by their energy, every ſecretion and excretion of the ſyſtem is performed;—the important function of reſpiration depends upon their exertion;—and they effect the various motions of the body, which are of ſo much utility in the different avocations of life. To render them capable of producing theſe effects, they are in a high degree endowed with that ſuſceptibility of the action of ſtimuli, upon which the commencement and continuance of life depends.

We are next to direct our attention more particularly towards the Nervous Syſtem.

The brain, or that maſs which fills the cavity of the cranium, is at once the origin and point of union to the whole nervous ſyſtem. This general maſs is divided into three particular portions,—the cerebrum,—the cerebellum,—and the medulla oblongata; and a continuation of the latter forms the medulla ſpinalis, which fills the cavity of the vertebræ. This organ, and the various branches derived from it, form one of the moſt important parts of the animal œconomy. It is eſſential to all the nobler ſpecies of animals; but its importance is more peculiarly evident in man than in any other. In the human race, it bears a much larger proportion to the ſize of the animal than in any of the inferior orders. The nerves, which form the various organs of ſenſation, and upon which ultimately the action of muſcular fibre depends, are derived from the brain in the inferior animals, as well as in man; but, from the much larger ſize of this organ in the latter, it appears deſtined to perform ſome other and more important purpoſes in him than in the former. The whole of the nerves, it has been obſerved, bear but a ſmall proportion to the maſs of medullary ſubſtance contained in the brain, being at leaſt an hundred times as large as the diameters of all the nerves of the head and ſpinal marrow. It does not appear that the large ſize of the brain gives to man more acute ſenſations, or a greater power to produce muſcular motion, than other animals poſſeſs, in which the brain is proportionally much leſs. Thus, as Dr Monro has obſerved, the brain of a large ox has been found to weigh not more than one fourth part of the human brain, whilſt the weight of the ox was probably ſix times greater than that of the man; or the brain of the man was, in proportion to his weight, twenty-four times heavier than that of the ox. At the ſame time, the nerves of the muſcles of an ox are in their ſize proportioned to the bulk of the animal's muſcles, and thoſe of the organs of ſenſation, as the eye and noſe, are proportioned to the extent of theſe organs. Thus the olfactory nerve of an ox is many times larger than that of a man. Again we obſerve, that three fourths of the nerves originate from the medulla ſpinalis; yet it is only a ſmall part of the brain which is elongated, and paſſes down the vertebral canal. We have reaſon therefore to conclude, that to give origin to the nerves is not the ſole uſe of the brain: it is the ſeat of intellect; the medium by which impreſſions made on the organs of ſenſation are conveyed to mind.

The whole of the nerves, then, ariſe from one common ſource; and the brain muſt be conſidered as the central point at which they all unite. Ariſing from this point, they are tranſmitted to every part of the body,—they are interwoven in every organ of ſenſation,—every muſcle, veſſel, and bone, and thus unite the various parts ſo as to conſtitute an uniform ſyſtem. Poſſeſſed of a peculiar organization, by which they are highly ſuſceptible of impreſſions from various ſtimuli, they receive impreſſions on every part, which appear to be inſtantaneouſly tranſmitted to the central point, the cenſorium commune. Hence it is, that the action of a ſtimulant upon a particular part does not affect that part only to which it is applied, but operates in a greater or leſſer degree upon the whole ſyſtem. Minute anatomy evidences, by an infinite variety of circumſtances, the peculiar fitneſs of the brain and nervous ſyſtem for producing theſe effects. We muſt not here enter into a particular deſcription of the anatomy of theſe parts; but we ſhall endeavour to illuſtrate the ſubject by a few general obſervations on the ſtructure of the brain and nerves, and the diſtribution of the latter through every part of the body.

We have obſerved, that the brain is formed of three portions, the cerebrum, cerebellum, and medulla oblongata, to which a fourth may be added, the medulla ſpinalis. The whole of theſe are covered by their peculiar membranes, the pia mater and dura mater. Theſe ſerve for their protection, and to convey blood-veſſels for their nouriſhment and ſupport. The brain is ſupplied with numerous blood-veſſels from the carotid and vertebral arteries; and by the many convolutions which they make before they paſs through the dura mater, and the vaſt number of communicating branches into which they are divided in the pia mater, and its proceſſes, it appears, that the blood muſt move more ſlowly and equally in thoſe veſſels than in thoſe of other parts: We may alſo add, that the arteries in other parts are in ſome degree acted upon by the labouring muſcles, and the preſſure of the atmoſphere, by which the blood is propelled with additional force. But the arteries which ſupply the brain, after they enter the cranium, are not ſubjected to the operation of theſe powers. We obſerve then, in this diſtribution of the blood-veſſels of the brain, a proviſion made againſt thoſe injuries which muſt have infallibly taken place in ſo delicate an organ, if it had been poſſible for the blood to have been driven into it with great violence. A very conſiderable quantity of blood is tranſmitted to the brain, —it is derived from trunks which ariſe near the heart;—and, according to the opinion of Haller, a ſixth part, or, as Dr Monro ſuppoſes, not leſs than a tenth part of the circulating maſs, is tranſmitted to the brain. From the ample ſupply of this fluid which the brain receives, it appears that perpetual and important changes take place in the ſubſtance of the brain and nerves, as well as in other parts.

The cerebrum, cerebellum, and ſpinal marrow, are naturally divided into the external part, the cortex or cineritious ſubſtance, and the internal part, or medullary matter. The minute branches of the blood-veſſels, by the aſſiſtance of injections and the microſcope, are found to paſs from the pia mater into the cortical part in vaſt numbers; in fact, it appears to be almoſt wholly formed of veſſels; but into the medullary ſubſtance we only obſerve longitudinal veſſels entering. The veins which return the blood from the brain are of a peculiar ſtructure, evidently deſigned to facilitate that return. Their coats are of peculiar ſtrength: they form innumerable anaſtomoſes with one another; and when collected ſo as to form conſiderable trunks, they are lodged in canals, which prevent them from being ſubjected to compreſſion. A proviſion therefore is evidently made to prevent an injurious accumulation of the blood in this organ. It has been doubted, whether the brain is ſupplied with lymphatics? They may certainly be demonſtrated upon the pia mater; and from analogy drawn from every other part of the body, we can ſcarcely ſuppoſe that the brain is deſtitute of lymphatics. Indeed modern phyſiologiſts in general admit the exiſtence of lymphatics in the brain.

From the blood-veſſels, as we have already hinted, the cortical part of the brain receives its origin. Anatomical injections fully prove, that the greater part of it conſiſts of veſſels which are inſerted from the ſmall branches of the pia mater. Theſe veſſels, however, in the natural ſtate, do not convey red blood, but a thinner fluid; although in ſome diſeaſes, and in death by ſtrangling, particularly in brutes and birds, the red blood is propelled into them. No anatomiſt has, indeed, ſucceeded in filling every portion of the cortex with injected matter; yet it is probable, that it is altogether vaſcular. We obſerve no diſſimilarity of parts in it when in the entire or natural ſtate, ſo that we cannot imagine that it is partly vaſcular and partly ſolid.

As the cortical ſubſtance originates from the veſſels of the pia mater, ſo the white medullary matter is derived from the cortex. The continuity of the medulla with the cortex, is diſtinctly ſeen by the microſcope, and may even be obſerved by the naked eye. Minute portions of the medulla may be obſerved proceeding from the cortex; and its gradual increaſe may be traced, becoming more broad and abundant till it makes up the whole oval ſection of the brain, and is bounded only by the convolutions of the cortex.

The medulla is extremely ſoft, and of a fibrous texture. The fibres are viſible in ſeveral parts of the human brain, and ſtill more evidently in the brains of fiſhes, eſpecially in their thalami optici. The fibres of the medullary ſubſtance are ſimply extended, ſo as to form the white fibrous cords which are diſtributed to every part of the body, and which are univerſally termed the nerves. That the fibres of the nerves are merely a continuation of thoſe of the medulla, is diſtinctly ſeen in the ſeventh, fourth, and fifth pairs of nerves.

The nerves, then, are compoſed of many fibrous threads, lying parallel, or nearly ſo, to each other, as they ſhoot off from the medulla. At the origin of moſt of the nerves within the ſkull, this fibrous texture is perceptible: and in the cauda equina of the ſpinal marrow, they may be divided into threads, ſo exceedingly minute, that they are ſcarcely viſible to the naked eye: yet even theſe fibres, when examined with a microſcope, appear to be formed of a conſiderable number of fibrils, much more minute.

It is perhaps not poſſible to eſtimate the ſize of the ſmalleſt of theſe fibres. Were the nerves, which are divided over the whole body, conjoined into a cord, the diameter would not be an inch; yet even the moſt minute part of the body is ſenſible: and this muſt depend on each particular point being ſupplied with nerve. We muſt therefore be convinced, that the nervous fibrils are aſtoniſhingly ſmall. Nay, it has been demonſtrated, from the extreme minute portions of matter which are viſible to the ſight, that each fibre in the retina of the eye cannot exceed in diameter the thirty-two thouſand four hundredth part of a hair.

The medullary matter, of which the nervous fibrils are formed, is exceedingly delicate and ſoft. They are therefore connected together by cellular ſubſtance, and protected from injury by coats formed of the dura and pia mater. Theſe nervous cords are ſo liberally ſupplied with blood-veſſels, that when their arteries only are injected, the whole cord appears to be tinged with the colour of the injected liquor.

The nerves, after being given out by the brain or ſpinal marrow, are generally, like the blood-veſſels, divided into branches: but they paſs off, or ſeparate, from each other in acute angles, and often in a retrograde direction. The fibrils of the nerves, however, are not ſplit at theſe diviſions ſo as to form ſmaller threads; but the original fibres, continued from the brain itſelf, recede from each other by an opening of the cellular ſubſtance by which they are united: ſo that, after the nervous fibril has left the brain, it appears, in fact, to undergo no change till its ultimate termination. The nervous cords generally appear to grow ſofter during their courſe, till at length, at their termination, they ſeem to be loſt in a mucus or pulp. Hence it has been ſuppoſed, that during their progreſs they depoſit the coats which they had received from the pia and dura mater; and that, to be capable of ſenſation, or the other purpoſes which the nerve is to effect in the ſyſtem, it is neceſſary that the medullary part ſhould be laid perfectly bare at its termination. It is, however, alledged by Dr Monro, that every filament of a nerve retains, at its termination, a covering of the pia mater, by the veſſels of which it is nouriſhed and preſerved in that ſtate, upon which the faculty of receiving impreſſions, and the power of action, depend.

In ſome inſtances we obſerve different nerves uniting ſo as to form one cord; this, in ſome meaſure, reſembles the inoſculations which take place in the ſanguiferous ſyſtem. After ſuch an union, we frequently find, particularly in thoſe which are diſtributed to the bowels, a hard knot is formed, conſiderably larger than the nerves which are thus united into a cord. Theſe knots are generally termed ganglions: They have thicker coats, and are more liberally ſupplied with blood-veſſels than the nerves. Dr Monro obſerves, that they are full of nervous fibrilli, intermixed with a yellowiſh or reddiſh brown ſubſtance, ſomewhat ſimilar to the cortical ſubſtance of the brain. Hence he ſuppoſes, that they are ſources of nervous matter or energy.

Derived from this origin, (the brain), we find forty pairs of nerves diſtributed through the body, viz. ten which immediately proceed from the encephalon, and thirty which paſs off from the medulla ſpinalis. Of theſe we find four proceeding immediately from the brain, which are deſtined to receive various impreſſions from external objects, by which the ſenſations of ſight, hearing, ſmell, and taſte are produced. The reſt are diſtributed to the various muſcles, and extended on the ſurface of the body, effecting the motion of the muſcular ſolid, and producing, in every part of the ſyſtem, by impreſſions from different ſubſtances, that ſenſation which we call feeling. To whatever purpoſe the nerve is applied, whether to receive ſenſation, or to excite motion, we do not perceive any difference in its ſtructure; it is in every inſtance formed of the ſame ſoft medullary fibre. We perceive, indeed, the optic nerve, at its termination, is extended into a delicate web, which covers the ſurface of the eye. The portio mollis alſo of the auditory nerve, is extended in a very ſoft pulpy form on the inner camera of the ear; but, excepting theſe two, we obſerve no variations in the external appearance of the nerves at their terminations: Nor do we diſcover, even in theſe, any peculiarities of ſtructure, by which we can be able to aſſign a reaſon why the one ſhould receive the rays of light, reflected from ſurrounding bodies, by which the ſenſation of ſight is produced; or why the other ſhould be affected by percuſſions of the air, ſo as to communicate the different ſenſations of ſound. We obſerve, indeed, that ſeveral of the nerves which are deſigned to communicate particular ſenſations to the mind, are furniſhed with peculiar apparatus. Such, we obſerve in the wonderful ſtructure of the eye; and in the ſtriking contrivance exhibited in the veſtible, cochlea, and ſemicircular canals of the ear. That theſe apparatus are eſſentially requiſite to enable the nervous matter to receive particular ſenſations, cannot be doubted: But it muſt remain as a queſtion which probably will never be determined, whether the medullary matter itſelf does not undergo ſome modification, by which it is fitted reſpectively to receive impreſſions from light, ſound, odorous or ſapid ſubſtances;—to diſtinguiſh the nature of other ſubſtances by what we call feeling,—or to excite the muſcular action. Whatever may be in this, we are certain, that ſenſation altogether, and muſcular motion in a great meaſure, are produced by the operation of various agents upon the nervous ſyſtem. If a nerve is irritated, acute pain is induced; and in proportion to the number of nerves with which any part of the body is ſupplied, it is poſſeſſed of a greater or leſſer ſenſibility. Thus, in the eye and the penis, which are plentifully ſupplied with nerves, the feeling is extremely acute; and the tendons, ligaments, bones, and cartilages, into which few nerves enter, have in the ſound ſtate little or no ſenſation. But if, on the other hand, the communication between the ſentient extremities of the nerves and the ſenſorium commune is obſtructed, as by the diviſion of the nerve, the ſenſation of the part beyond the diviſion is entirely deſtroyed.

Having thus taken a curſory view of the various parts of which the body is compoſed, and having briefly pointed out the reſpective uſes of each, we proceed, ſecondly, to ſhow, that by the union of the various parts of the animal body, a complete and indiviſible whole is formed, ſo that any agent which operates upon a particular part, muſt in a greater or leſſer degree affect the whole.

By the union of the various parts of the animal body, an indiviſible organic ſyſtem is conſtituted. While this organization ſubſiſts, and the proper powers act upon it, life continues; and the living principle is preciſely the ſame, one and undivided, in every part of the ſyſtem. This unity, as we have already ſaid, is effected by the univerſal diſtribution of the nerves to every part of the body. It is impoſſible to account for the effects produced by the action of all or any one of theſe powers, which are capable of operating upon the body, excepting from this fact, that it forms an indiviſible whole. As this is a point of conſiderable importance in phyſiology and the practice of medicine, it is proper to illuſtrate it, by mentioning a few facts, which fully prove that no power can operate upon any part of the body without producing ſimilar effects in a greater or leſſer degree throughout its whole ſubſtance. And firſt, If a ſtimulus is applied to any part of the ſyſtem, the whole is, in a certain period, brought into the ſame ſtate as the part to which the ſtimulus was directly applied. The action of the ſtimulus is indeed firſt exerted on the organization of the part to which it is immediately applied; and if it is of that claſs of ſtimuli which produces a temporary energy in the ſyſtem, as alcohol or opium, we find that vigour is induced, or the action of the ſyſtem is firſt excited in that part to which the application of the ſtimulus is made; but in a ſhort period the ſame energy is produced throughout the ſyſtem. On the contrary, if any power which is capable of producing a debilitating effect is applied to a particular part, debility is immediately produced in that part; but it will quickly be extended in a certain degree over the whole. It is true, every part of the body is not equally ſuſceptible of the action of ſtimuli. The brain and the alimentary canal, for example, are more powerfully acted upon by a given ſtimulus than the ſurface of the body. But this does not ariſe from any eſſential difference in the organization of theſe various parts, by which the former are ſuſceptible of the action of the ſtimulant, and the latter not; for they are all capable of receiving a ſimilar impreſſion, though differing in degree. It ariſes then merely from the organization on the ſuperficies of the body being ſo modified as to render it leſs ſuſceptible of the action of ſtimuli than the brain or ſtomach. The ſame reaſoning applies to all the varieties which we obſerve in the action of different powers, whether the healthful or the morbid, upon various parts of the body.

The unity of the ſyſtem is again ſufficiently proved by the effects produced by a debilitating power being applied to any part of the body. We obſerve theſe effects moſt ſtrikingly in perſons whoſe organization is delicate and feeble. In theſe the application of ſuch debilitating powers will produce deliquium animi. Thus certain odours will induce this effect. A blow on, or ſtrong compreſſion of the points of the fingers, will alſo induce deliquium animi. In ſome inſtances, the continued operation of theſe powers, and perhaps in all, if the degree of their action is ſomewhat increaſed, life will be deſtroyed. Upon the other hand, if the vital functions have not been too long ſuſpended, the application of a gentle ſtimulus to any part of the body, will reproduce the exerciſe of theſe functions. This ſympathy, which we obſerve in all theſe caſes between the various parts of the body, cannot be accounted for except we admit, that throughout the ſyſtem there is a ſameneſs of ſtructure, and univerſal unity of ſubſtance; ſo that if any part be affected, the whole ſyſtem muſt more or leſs ſuffer, in proportion to the degree in which the injurious power operates.

The indiviſibility of the body is farther proved, by the phenomena of various diſeaſes. Thus vomiting is frequently produced by the preſence of biliary concretions in the gall ducts, or by calculi in the kidneys, ureters, or bladder of urine. This ſympathy, ſubſiſting between the ſtomach and the part to which the irritating ſubſtance is applied, can only be explained upon the principles which we have juſt ſtated.—So alſo injuries received by the head, frequently produce vomiting, and ſpaſms of the muſcles in the oppoſite ſide of the body to that upon which the injury was applied; which ſtrictly proves, that the brain is an indiviſible maſs, and that all the nerves are merely a continuation of it.—Spaſmodic affections alſo, of many of the voluntary muſcles, often occur during ſevere vomiting and purging.—In like manner, a wound in any of the extremities, and even in the moſt diſtant part of an extremity, will produce a locked jaw. The whole of theſe effects can only be accounted for, on the ſuppoſition, that by the univerſal diſtribution of the medullary fibre, every part of the body is united, ſo as to conſtitute an indiviſible whole.

This ſubject may be farther illuſtrated, by the effects produced on the body by the operation of the more powerful articles of the Materia Medica. A large doze of opium taken into the ſtomach, will entirely deſtroy ſenſibility in every part, and quickly produce death; and the ſame ſubſtance, when employed in a proper quantity, will procure an abatement of pain in the moſt diſtant parts, and will remove a ſpaſmodic affection of all or any muſcle of the body.—It may be added, that a given quantity of opium, injected into the rectum, will not produce the ſame effect in relieving painful ſenſations,

tions, or in removing ſpaſm, as if it had been received into the ſtomach. We have already aſſigned the cauſe:—The organization of the rectum does not eſſentially differ from that of the ſtomach, but, from its peculiar modification, it is not ſo ſuſceptible of the action of ſtimuli as the internal ſurface of the ſtomach. But a ſufficiently large doze of opium injected into the rectum, would as infallibly deſtroy life, as a ſmaller when received into the ſtomach. Nor are the deleterious effects of opium, or any other ſubſtance, produced by theſe matters being applied to every part of the ſyſtem, but merely by their action upon any part of the organized matter. It was indeed at one time a generally received opinion, that no article whatever could produce death, unleſs it entered the general maſs of circulating fluids, and was by that means conveyed to every part of the body, or at leaſt to the nobler parts. But we have the moſt demonſtrative evidence, that theſe deleterious effects are produced without a particle of the poiſonous matter being mixed with the circulating fluids. Thus, if the ſciatic nerve of a frog is laid bare, and a ſolution of opium is applied, the life of the animal is immediately deſtroyed.—Now, if the ſame experiment is performed upon a frog, the heart of which has been previouſly cut out, ſo that the circulation is entirely interrupted, the ſame effect will be produced. This experiment affords a clear proof that the poiſon was not conveyed by the circulating fluids. We have alſo formerly noticed, that inſtantaneous death is produced in the ſtrongeſt man by a ſingle drop of the oleum lauro-cerafi being received into the ſtomach; and in this caſe, neither the quantity of matter received, nor the period required to produce death, will permit the ſuppoſition, either that the poiſon has been received into, or that it is tranſmitted by the circulating fluids. We muſt be ſatisfied that the poiſon acts upon that part of the organized ſubſtance with which it is immediately in contact, and that its effects are tranſmitted with ſuch aſtoniſhing celerity through every part of the ſyſtem, becauſe that ſyſtem is perfectly indiviſible.

The influence of the mental energy upon all the voluntary muſcles, affords another clear proof of the indiviſibility of the body. The determination of the mind to perform a particular action, is frequently inſtantaneous; and no ſenſible point of time intervenes between the mental determination, and the muſcular motion by which the action is performed. In ſome inſtances, the effect ſo inſtantaneouſly accompanies the determination of the will, that we are almoſt ready to aſcribe it to a mechanical operation, rather than to mental volition. Thus, the motion of the limbs in dancing, is ſo perfectly ſynchronous with the ſound of the muſic, that we can ſcarcely obſerve any exertion of the mental faculty. Yet in this caſe we eaſily perceive that the ſound muſt have acted upon the auditory nerve, — the ſenſation muſt have been tranſmitted to the ſenſorium commune,— and the determination of the will, in conſequence of this ſenſation, muſt, in the order of things, have preceded the muſcular motion. In the order of time, however, we cannot, by the moſt accurate examination, perceive that the ſound of the muſic precedes, in the leaſt degree, the laſt effect produced, viz. the motion of the limbs. Can we poſſibly account for the inſtantaneous effect produced on the bodily organs by the mental deciſion, except on the principles here ſtated?

As a laſt and equally deciſive proof of the indiviſibility of the body, we may mention that relation which ſubſiſts between it and the paſſions of the mind. Agreeable paſſions, or the paſſions reſtrained within moderate bounds, produce the ſame beneficial effects upon the body as the other healthful or natural ſtimuli. But when theſe are excited to a conſiderable degree, ſo as to produce, for example, exceſſive joy or extreme grief, we find that their effects are as injurious to the body as the moſt powerful external agents, producing various effects, as debility, mania, and even death, in proportion to their nature, and the degree of their action; on the contrary, if the organization of the body is conſiderably affected, a mental imbecility, or a total derangement of the mental functions, not unfrequently follow. Theſe facts ſufficiently ſhow the intimate connection which ſubſiſts between the mental functions and the bodily organization; and afford no indeciſive proof, that the organized matter of animal bodies muſt be conſidered as forming an indiviſible ſyſtem. And, as we have already ſaid, while this organization continues, and the proper powers act upon it, life continues, and the living principle is preciſely the ſame, and undivided in every part of the ſyſtem.

The human body then, although made up of parts that are ſeemingly diſſimilar, particularly with regard to ſtructure, appears to be a complete whole; and each of theſe parts, from the peculiar modification of its organization, is admirably fitted for performing the purpoſe to which it is deſtined. The bones, cartilages, and the cellular ſubſtance, are leſs ſuſceptible of the action of ſtimuli than the muſcular and nervous fibre. Theſe laſt form the moſt important parts of the body, and upon them the action of every power is moſt eminently exerted. At the ſame time, no agent can operate upon any part of the body, whatever may be the peculiar modification of organization in that part, without the whole being ultimately affected.

We go on, thirdly, to offer ſome general obſervations on the nature of excitability; or that principle which appears to exiſt in every part of the body, and by which it is rendered ſuſceptible of the action of various agents.

The ſubject of animal life is a ſimple uniform organized body. But, as we have ſaid, no mode of organization whatever is ſufficient to produce the phenomena of life, unleſs certain peculiar agents operate upon this organization: and theſe agents muſt be accommodated, both in their quality, and in the degree of their operation, to the peculiar ſtructure of the organized ſubſtance. Thus life is produced and continued by the healthful or natural ſtimuli acting in due proportion. By totally abſtracting all or any of theſe ſtimuli, or by their acting in too great a degree, the functions of life are impaired, and at length totally deſtroyed. By the action of any of the morbid ſtimuli, health is injured; and when they operate to a certain extent, the powers of life are entirely extinguiſhed. Again, when injurious effects have been induced by the abſtraction or too forcible operation of the natural ſtimuli, or by the action of the morbid ſtimuli; theſe injurious effects may be obviated, and the health of the ſyſtem reſtored, by employing the artificial ſtimuli in due proportion. Theſe facts fully prove that the phenomena of life are produced by the operation of certain agents upon organized matter. The phenomena, from the preſence of which we can infer the exiſtence of animation or life, are, in the inferior orders of animals, ſenſation and motion. In man, we may add to theſe, the exerciſe of the mental functions. Yet if none of theſe are preſent, we cannot abſolutely conclude that life is extinguiſhed, while no material alteration has taken place in the bodily organization. Daily obſervation furniſhes us with many facts that prove the poſſibility of producing the phenomena of life, after they have been ſuſpended for a longer or ſhorter period. But the ſame facts alſo furniſh the moſt deciſive evidence that this reproduction of life is ſolely effected by the action of ſtimuli upon the bodily organization. In the partial and very temporary ſuſpenſion of the vital functions during deliquium animi, we ſee an example of the organization being ſo far injured, as not to be ſuſceptible of the action of the ordinary healthful ſtimuli. In theſe caſes, the reproduction of all the vital functions is at leaſt facilitated by employing ſome of the more powerful of the artificial ſtimuli. Again, in that ſuſpenſion of the vital functions, for a longer or ſhorter period, produced by ſubmerſion, we obſerve the phenomena of life to diſappear, ſimply by the abſtraction of the ſtimulus of air. This is one of the natural ſtimuli, the perpetual action of which (on principles which we are ſhortly to explain), is neceſſary for the continuance of life. This ſtimulus may be abſtracted for a certain time, without the organization undergoing any material alteration. When the body is taken out of the water, it is indeed incapable of being acted upon by the ordinary healthful ſtimuli: and if the artificial ſtimuli, in various modes, are not employed, the different animal functions will no more be called into action. In this caſe, the reproduction of the phenomena of life, evidently depends upon the action of ſtimuli. It deſerves here to be remarked, that one of the moſt important of theſe is the artificial introduction of one of the natural ſtimuli, viz. air, into the lungs. Perhaps the moſt important agent in theſe caſes, in reſtoring the tone of the fibre, ſo as to render it capable of being acted upon by the healthful ſtimili, is heat. Animal heat is chiefly, if not wholly, ſupplied by the reſpiratory function: and if reſpiration has been too long obſtructed by ſubmerſion, or, in other words, if the ſtimulus of heat has been too long abſtracted from the animal body; we find the organization is ſo much deranged, that it is no longer ſuſceptible of the action of the moſt powerful ſtimuli, whether natural or artificial; and the powers of life are for ever extinguiſhed.

That the production of the phenomena of life depends upon the action of ſtimuli upon the bodily organization, may be further illuſtrated, by many experiments which have been made upon organized matter, even after the functions of life have ceaſed. Thus we find that the muſcular fibre, even when ſeparated from the ſyſtem, may be excited to action, by mechanical and chemical ſtimuli, for a conſiderable length of time after the apparent death of the animal, or after the ſeparation from the ſyſtem of the particular portion of muſcular fibre upon which the experiment is performed. It was indeed formerly ſuppoſed, that this property of being excited to action after apparent death, was confined to the muſcular or irritable fibre: but the influence recently diſcovered by Galvani, clearly ſhows that the medullary fibre alſo is ſuſceptible of the action of ſtimuli after the functions of life have apparently ceaſed. In the experiments upon animal electricity, as it has been improperly called, it is ſufficiently plain, that two or more metals, when brought into contact, are capable of producing a peculiar and powerfully ſtimulating effect upon the organs of ſenſation and motion, whether in the perfectly living ſtate, or after apparent death. But even theſe metallic ſtimuli, however powerful, ceaſe to excite either the medullary or muſcular fibre, when the organization has undergone a certain degree of derangement.

It may be further obſerved, in proof of this doctrine, that the ſuſceptibility of the animal fibre for the action of ſtimuli, after the phenomena of life have ceaſed, is extremely varied in different ſubjects. The degree of its ſuſceptibility depends upon the greater or leſſer degree of derangement in the organization produced by the immediate cauſe of death. For example, the fibre of a perſon whoſe life has been deſtroyed by certain ſpecies of poiſon, is much leſs capable of being excited by ſtimuli, than that of a perſon dying by ſeveral ordinary diſeaſes, or of one whoſe life may have been ſuddenly taken away, in a ſtate of health, by ſtrangling, or other modes by which the organization has not undergone any material injury *. Theſe varieties in the

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* Dr Girtanner has attributed, as we have already noticed, theſe variations in the excitability or irritabili-

ſtate of the animal fibre in different ſubjects, after the ceſſation of the ordinary phenomena of life, cannot be accounted for, excepting on the ſuppoſition that the organization has undergone different degrees of derangement by the various cauſes of death.

During the continuance of life, we frequently ſee the ſtate of the fibre extremely varied, with reſpect to its ſuſceptibility of the action of ſtimuli, by different diſeaſes. Paralyſis affords a very ſtriking illuſtration of this obſervation. We ſee a perſon apparently enjoying the fulleſt ſtate of health,—the vital functions ſeemingly in

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ty of the muſcular fibre, to the abſtraction or addition of oxygene. This opinion is merely hypothetical. Oxygene may indeed be extracted from the muſcular fibre after death; and it would perhaps be worth while to try the experiment, whether as much oxygene may not be obtained from the muſcular fibre of an animal, the life of which has been deſtroyed by one of the Doctor's poſitive ſtimuli, as from an equal quantity of the muſcular fibre of another animal, the life of which has been taken away by one of his negative ſtimuli. I ſuſpect ſuch an experiment would entirely overthrow Dr Girtanner's theory.

in the moſt perfect exerciſe,—and all the life-ſupporting powers acting upon him with their uſual force,—when ſuddenly, ſome of his muſcles loſe the power of motion. To what cauſe are we to aſcribe this change? Certainly to a change in the organization of the part, by which it is rendered incapable of being acted upon by the natural ſtimuli. How are we to remove the diſeaſe?—If it is remediable, every one will admit, that the effect can only be produced by employing the natural and artificial ſtimuli in due proportion.

In every view that we can take of this ſubject, it appears then, that the phenomena of life can only be produced in bodies peculiarly organized; and that theſe phenomena commence, and are continued, by the operation of certain agents, the action of which muſt bear a fixed proportion to the ſtate of the organization. Upon theſe ſimple principles we account for animation; and the theory we find ſupported by all the phenomena of nature which paſs under our obſervation, and by all the experiments which we can perform upon organized ſubſtances. In vain then ſhall we ſearch for any principle of life, excepting the action of theſe agents upon matter which, by its peculiar ſtructure, is ſuſceptible of their operation. The ſuſpenſion of reſpiration, and the ceſſation of the action of the heart, have, by ſome, been ſuppoſed the cauſe of death: But in fact theſe vital functions never ceaſe, unleſs the powers which, by their ſtimulus, excite their action, have been abſtracted, or that the organization has ſuffered ſuch a derangement as to render the body unſuſceptible of the action of theſe powers. In either caſe, the ceſſation of action in the heart and lungs is merely an effect, not a cauſe of death: and that effect is either ſimply a conſequence of a faulty action of the life-ſupporting powers, or a derangement of the bodily organization.

From the facts here adduced we may warrantably conclude, that it is only by the various modifications to which the animal fibre is liable, that we can explain all the phenomena of health and diſeaſe. It is by the different ſtates of the organization that the various ſtages of animal life are formed, as infancy, childhood, youth, manhood, and old age. The various modifications which take place in the fibre during theſe periods, render the operation of ſtimuli upon the body exceedingly different. At the ſame time we ſhall find, that theſe different modifications of the organization are, in a great meaſure, produced by the continued operation of the healthful or natural ſtimuli upon the body.

The ſuſceptibility which we obſerve in animal bodies, of being acted upon, and excited to action, by various agents, has been termed excitability. The powers which produce this effect are conſequently named exciting powers; and the effect produced by their action is ſtyled excitement, or the ſtate of excitement.

Excitability is then a property inherent in living matter. We have aſcribed it to a peculiar organization; and the varieties which we obſerve in the phenomena of life, as they appear in different orders of animals and vegetables, we alſo refer to the different modifications of that organization. That excitability peculiarly belongs to organized matter, is a fact, for the truth of which we have ocular demonſtration; and it is an ultimate fact, beyond which it ſeems impoſſible for human reſearch to be extended.

It will from hence follow, that the ſtate of the organization will, in all caſes, expreſs the ſtate of the excitability. The latter will always vary according to the different modifications which the former undergoes; or, in other words, the ſtate of the organization and the ſtate of excitability are convertible terms.

To illuſtrate this ſubject, we ſhall endeavour to conſider the principle of excitability, or the ſtate of the animal organization, in ſeveral points of view; and firſt, as it appears in an individual at the three different periods of life, infancy, manhood, and old age.

Infancy is diſtinguiſhed by a weak and delicate organization: the weakeſt ſtimulus, and in the ſmalleſt quantity, is capable of exciting action in the ſyſtem; and hence nature has provided, in the mother's milk, a mild nutritious fluid for its ſupport. The weak ſtate of the animal fibre, renders it impoſſible to produce in the infant ſyſtem vigour of body, or that ſtate which has been termed high excitement. Hence the ſuſceptibility of being excited by different agents, whether natural or artificial, is, by their too powerful operation, quickly deſtroyed. A full meal of the mother's milk, or other mild ſubſtances, ſoon induces ſleep; and a very ſmall doſe of the ſtronger ſtimuli, as alcohol or opium, will immediately deſtroy life, or utterly exhauſt the excitable principle. Theſe facts lead to a plain concluſion, that a high ſtate of excitability implies a feeble organization. It follows alſo, that the operation of thoſe agents which produce action in the ſyſtem, eventually deſtroys its capacity for being excited. Too great a quantity of the moſt proper food ſoon produces debility in the infant fibre; and, as we have juſt ſaid, the more powerful ſtimulants, in a very minute proportion, will quickly ſo much derange the organization, as to render it incapable of being excited.

In ſome of the ſucceeding pages, we ſhall have occaſion particularly to ſhow, that many of thoſe agents, the operation of which is neceſſary to the production and continuance of life, do not act merely as ſimple ſtimulants, but that, by the addition of new matter, they communicate vigour to the body, and hence preſerve the animal exiſtence. Such is the uſe of aliment in general. The infant fibre is ſo modified, as to be capable, by the action of the healthful agents in juſt proportion, particularly aliment, to receive an acceſſion of new matter, to increaſe in ſize, and to acquire a more vigorous organization. Hence the body becomes leſs ſuſceptible of the action of ſtimuli: it requires a greater proportion of theſe agents to produce the uſual effect; or, in other words, the excitability is diminiſhed, and the ſyſtem becomes capable of a higher degree of excitement.

As the too powerful action of ſtimuli, whether natural or artificial, quickly deranges the infant organization, or exhauſts the excitability, ſo alſo that principle is rapidly accumulated by the abſtraction of the healthful agents. From the feeble ſtate of the animal fibre in this period of life, it follows, that any abſtraction of the uſual neceſſary ſtimuli will induce weakneſs in the organization; and if this abſtraction is carried to a certain extent, life is deſtroyed.

Here it muſt be remarked, that we do not perceive any very material difference in the effects produced on the animal body by theſe two ſeemingly oppoſite cauſes, the too powerful action, or the total abſtraction of ſtimuli. It is obvious, that each of theſe cauſes produces debility: The effect of the firſt has been termed

indirect,

indirect, and that of the ſecond, direct debility. Perhaps it is proper that ſome diſtinctive terms ſhould be employed to denote the effects of cauſes ſo different, although ultimately their effects appear to be preciſely the ſame. We ſhall have occaſion again to advert to this point, and ſhall therefore only obſerve at preſent, in illuſtration of the ſubject, firſt, that the operation of ſtimuli muſt be various, in proportion to the degree of their action. When employed in a moderate degree, or juſt proportion, they do certainly exhauſt the excitability, or render the ſyſtem leſs ſuſceptible of their action. But in this caſe that ſuſceptibility is quickly reſtored, and brought to the healthful point, by reſt, and the acceſſion of new matter from the aliment. If, again, ſtimuli are employed in too great, though not in extreme proportion, the ſuſceptibility of excitation is ſtill more rapidly, and to a greater degree, diminiſhed; but no ſooner has the operation of the ſtimuli completely ceaſed, than we perceive a conſiderable degree of weakneſs induced, attended with a high degree of excitability. But if the operation of the ſtimuli is in the extreme, the excitability is totally deſtroyed, i. e. the powers of life are annihilated. Secondly, by the abſtraction of the uſual ſtimuli in any degree, the ſuſceptibility of excitation in the ſyſtem is proportionally increaſed, till, by the continuance of that abſtraction, the excitability totally diſappears. We ſee then the moſt ſtriking analogy in the effects produced by the too powerful action, and the total abſtraction, of the neceſſary ſtimuli. In both caſes, the organization may be ſo far deranged as to produce death; but if the operation or abſtraction of the ſtimuli is not carried to this extent, in both caſes debility is induced, attended with an increaſed ſuſceptibility of the action of ſtimuli, or, in other words, a high excitability. There appears then to be no eſſential difference in thoſe ſtates of weakneſs which have been termed indirect and direct debility. This point we ſhall afterwards take occaſion to illuſtrate by examples.

By ſlow degrees, through the acceſſion of new matter, the infant organization acquires firmneſs and vigour, till at length the animal body acquires its higheſt degree of perfection, conſtituting the ſtate of manhood. In proportion to the increaſed vigour of the organization, the excitability is diminiſhed. To produce action in the ſyſtem, the force of the ſtimuli muſt be augmented: and the body can, with impunity, ſuſtain the action of more powerful agents. The animal functions are carried on in their greateſt degree of perfection; and the excitement or vigour of the ſyſtem has attained its utmoſt poſſible height. The body is, however, as in the former period, liable to the ſame deviations from the healthful ſtate, by the ſuperabundant or diminiſhed action of the different agents. But we obſerve a material change to have taken place: the animal body, having acquired its higheſt degree of perfection, is only capable of having the vigour of its organization renewed by receiving new matter from the aliment, but is incapable of any further increaſe of ſize. Increaſed obeſity is no contradiction to this fact; becauſe, when carried to a certain extent, it undoubtedly conſtitutes diſeaſe.

As it is evident that the operation of ſtimuli, even of thoſe which ſupply new matter to the body, has a continual tendency to exhauſt the excitability, we muſt be convinced, that it is to the continued action, through the progreſs of life, of thoſe agents, the operation of which is neceſſary to the production and continuance of that life, that we are to aſcribe the ſtate of weakneſs which conſtitutes old age. This period is marked by a debilitated organization, materially different, however, from the feeble organization of infancy; becauſe, from the alteration which the animal fibre has undergone, it has become, in a conſiderable degree, incapable of being recruited, or reſtored to the healthful ſtate, by the addition of new matter from the aliment. In vain ſhall we endeavour to account for this new modification which has taken place in the organic ſtructure of the body. The anatomiſt may point out ſome difference in the appearance of the parts in old age, and the former periods of life; and the chemiſt may demonſtrate ſome variation in the proportion of the conſtituents: but their moſt diligent reſearches can afford us no information as to the cauſe of this alteration: And we are conſtrained to admit, that human inveſtigation can carry us no farther than the bare knowledge of the fact, that in the more advanced periods of life, the powers of the ſyſtem, in carrying on the animalizing proceſs, are progreſſively diminiſhed, till at length the animal fibre becomes abſolutely incapable of aſſimilating or receiving new matter, and life neceſſarily ceaſes.

Old age is alſo obviouſly marked by diminiſhed excitability. This, in moſt inſtances, is ſtrikingly exemplified, by a diminiſhed ſuſceptibility of the action of ſtimuli in the various organs of ſenſation. Light no longer produces its former effect upon the eye, nor ſound upon the ear. The taſte and ſmell decay, and the feeling becomes obſcure. More evident proofs of diminiſhed excitability cannot be ſuppoſed. Yet, in another view, an accumulation of this principle ſeems to attend old age. The operation of the more powerful ſtimuli, as alcohol or opium, produces a greater effect than in the middle period of life. A quantity of alcohol, which, at forty years of age, would ſcarcely have cauſed exhilaration, will, in the ſame perſon, at ſixty or ſeventy years of age, produce intoxication. Hence it would appear, that old age, generally ſpeaking, exhibits ſigns both of an exhauſted and an accumulated excitability. With reſpect to the former, it appears, that the organization is ſo far deranged, as to be leſs ſuſceptible of the action of many of the external agents, as light, ſound, &c. With regard to the latter, the apparent accumulation of the excitable principle, we are inclined to account for it, from the conſideration of the fact juſt mentioned, that the animal fibre daily becomes more and more incapable of receiving new matter. This operates preciſely in the ſame way as the abſtraction of the neceſſary ſtimuli in the former periods of life. Hence the daily increaſed debility, and the conſequent increaſed ſuſceptibility of the action of ſtimuli.

In the progreſs of human life, we obſerve, by ſhades almoſt imperceptible, the feeble organization of infancy, riſing to the firm and vigorous tone of manhood, and again ſinking into the debility of old age. Through all the various modifications which take place in the fibre, we perceive the animal body more ſuſceptible of the action of ſtimuli, in proportion to the weakneſs of the fibre, and leſs ſuſceptible of that action, in proportion to its ſtrength. To what then are we to aſcribe the accumulation or exhauſtion of excitability, but to the various modifications of the organization? And to what are we to aſcribe theſe various modifications, (we ſpeak only of the ſtate of health), unleſs to the progreſſive capacity and incapacity of the animal fibre for receiving an acceſſion of new matter?

But the addition of new matter alone is not ſufficient to preſerve the animal fibre in the healthful ſtate; reſt is alſo required: and nature has allotted a conſiderable portion of our time to this purpoſe. The periods of watching and of ſleep very clearly exhibit the diminution and increaſe of the excitable principle. We go on, therefore, to conſider the principle of excitability, or the modifications which take place in the organization, in a ſecond point of view, viz. as producing the alternation of the waking and ſleeping ſtates.

It ſeems clear, that through the courſe of the day, or during the continuance of the waking ſtate, the organization becomes debilitated by the action of the ordinary ſtimuli, as heat, light, ſound, air; but eſpecially muſcular motion, and the paſſions of the mind. After theſe have acted upon the body for a certain period, it becomes no longer ſuſceptible of the action of theſe ſtimuli. An inert ſtate ſucceeds, in which we perceive a partial ſuſpenſion of the animal functions. The ordinary ſtimuli, during this period, have little or no effect upon the body, at leaſt none of thoſe functions are exerciſed which depend upon the will.

That the excitable principle is in this caſe exhauſted by the continued action of the ſtimuli ſeems clear, becauſe the ſame effect may be produced, and with ſtill greater celerity, by the exceſſive action of various ſtimulant powers. Thus too large a proportion of aliment, or the operation of heat in a certain degree, will induce ſleep. Still more rapidly is this effect produced by the action of the more powerful artificial agents, as opium, alcohol, &c. Since then ſleep is rapidly produced by the operation of powerful ſtimuli, we may reaſonably infer, firſt, that this ſtate neceſſarily ſucceeds the exhauſtion of the excitability to a certain degree; and, ſecondly,

condly, that in all caſes it is effected by the action of ſtimuli. The ſame effect which follows the operation of the more powerful ſtimuli in a ſhort period, is in a longer time produced by the ordinary healthful agents.

We cannot however aſcribe the ſtate of ſleep, in every caſe, to a ſimply ſtimulant action in the powers which produce it. By the labours of the day, a conſiderable quantity of matter is ſeparated, and thrown out of the body, by the various excretions. The animal fibre is weakened by the loſs of this matter: and hence it is, that although the more powerful ſtimulants will produce the ſtate of ſleep, yet the ſame ſubſtances, adminiſtered in a proper proportion, will preſerve the waking ſtate. Thus a perſon exhauſted by labour and long watching, may be kept awake for a further time by a moderate meal. In like manner, a doſe of opium or alcohol will protract the waking ſtate. Now, although the natural aliment does not furniſh new matter to the ſyſtem at the inſtant it is received into the ſtomach, and although opium and alcohol do not contribute new matter to the body; yet the whole of theſe produce a temporary vigour and energy in the ſyſtem, which for a ſhort time renders it ſuſceptible of the action of the natural ſtimuli, and hence the waking ſtate is protracted.

The ſtate of ſleep may then be produced by two cauſes: Firſt, The organization is debilitated by the ſtimulus of labour, and the other agents, during which a quantity of matter is ſeparated from the animal fibre, and not ſufficiently replaced. For although we receive aliment repeatedly during the day, it is at leaſt probable that the new matter is not depoſited during that period in the ſame proportion in which it is carried off. Hence the organization is weakened, producing in fact that ſtate which has been termed direct debility. But we believe it has not hitherto been ſuſpected, that the powers operating upon the body through the day really produce that ſtate.

Secondly, The ſleeping ſtate is induced by the operation of the more powerful ſtimuli, during which we do not perceive that the animal fibre is exhauſted by the diminution of matter; but the organization is debilitated by the exceſſive action of the ſtimulus producing what has been termed indirect debility. In both caſes, a debilitated organization appears to be the cauſe of ſleep.

We have already ſuggeſted, that there does not appear to be ſo great a difference between direct and indirect debility as has been very generally ſuppoſed. Direct debility is cauſed by the abſtraction of thoſe agents which are neceſſary to the continuance of life. To take aliment for our example,—Debility is ſoon induced by the total abſtraction of food. The cauſe here is perfectly obvious: The matter of the animal fibre is diminiſhed by the uſual excretions, and it has not received a new ſupply. Hence the weakened organization. Indirect debility is produced by the exceſſive action of ſtimuli. Is it not the neceſſary effect of ſtimuli, eſpecially the more powerful, to increaſe the ſecretions and excretions? May we not then ſuppoſe, that the more powerful ſtimulants rapidly diminiſh the matter of the animal fibre by accelerating the ſecretions, thus producing preciſely the ſame effect with the abſtraction of aliment? Is it not probable that the weak organization which follows the abſtraction of aliment, and the exceſſive action of alcohol or opium, is in a great meaſure produced by the diminution of the matter of the animal fibre? We are aware, however, that all the effects produced by the operation of ſtrong ſtimulants cannot be accounted for merely on the ſuppoſition of the abſtraction of matter from the body by the ordinary excretions. Nor can the effects which ariſe from the total abſtraction of ſeveral of the natural ſtimuli be accounted for on this principle. The abſtraction of air, for example, will in a very ſhort period produce death; and in this caſe no conſiderable diminution of the conſtituents of the body takes place. Nor is there any ſuch diminution when death is produced by a large doſe of alcohol or opium. It follows, that we cannot account for the action of all ſtimuli upon the ſame principles: and we ſhall have occaſion, when treating on the different agents, to ſhow, that various ſtimuli differ not only in the degree of their power, but alſo in their nature and mode of operation. We are however diſpoſed to think, that a debilitated organization, whether cauſed by the abſtraction or the too powerful action of ſtimuli, i. e. both direct and indirect debility, ariſes, generally ſpeaking, from too great a diminution of the animal matter.

Whatever may be in the preceding obſervations, it is plain that the ſtate of ſleep, in every inſtance, takes place in conſequence of an enfeebled organization. Upon this principle, we can explain the cauſe why ſleep is induced by the abſtraction of heat. A perſon ſubjected to a very low temperature, eſpecially if not ſtimulated by action, quickly becomes drowſy. The abſtraction of the neceſſary ſtimulus of heat debilitates the fibre.

Debility then produces that partial ſuſpenſion of the animal functions which we term ſleep. In this ſtate, the body is ſubjected only to the ſtimulus of the blood,—the other fluids,—the air in reſpiration,—and external heat, according to the degree of temperature in which the body is placed. In proportion to the debility induced, or previous exhauſtion of the excitability, provided the organization is not too much weakened, will be the ſoundneſs and continuance of the ſleep. After continuing in this ſtate for a certain period, the ſuſceptibility of impreſſions from the uſual ſtimuli is reſtored to the body. This reproduction of the excitability, appears to be cauſed by the abſtraction of the uſual ſtimuli which had acted upon the body during the waking ſtate, together with the addition of new matter to the fibre, by the animalizing proceſs which is carried on during ſleep, in the circulating fluids. Hence, new energy is communicated to the ſyſtem, the tone of the fibre is reſtored, and it is rendered capable of being excited by the natural ſtimuli. It requires no arguments to prove that the vigour of the ſyſtem is reſtored by ſleep: and it is plain that the action of ſtimuli, during the day, renders the body leſs capable of excitement in the evening, than it was in the morning. It follows then, that a particular modification of the organization being induced, and which appears to be a certain degree of debility, the excitability of the ſyſtem is conſiderably diminiſhed. But it muſt be here remarked, that a further degree of weakneſs than that which is neceſſary to induce ſleep, is accompanied with an accumulated excitability, ſo that the body becomes much more ſuſceptible of the action of ſtimuli, and the waking ſtate is protracted ſo as to conſtitute diſeaſe. Thus, a debilitated organization, in moſt inſtances, is attended with watchfulneſs or diſturbed ſleep. Now, when the waking ſtate is unduly protracted, or the ſleep broken and diſturbed, it ſeems clear, either that the excitability is conſiderably accumulated, or that the ſyſtem is ſubjected to the operation of powerful ſtimuli. In every inſtance, perhaps, of this kind, where the waking ſtate is not continued by the action of ſtimuli, the cauſe is ſufficiently obvious, a debilitated organization, which conſequently indicates an accumulated excitability.

Beſide the more powerful ſtimuli already mentioned, the ſleeping ſtate may be prevented, and a morbid watchfulneſs induced, by exceſſive fatigue or the depreſſing paſſions. In the firſt caſe, a high degree of debility is induced by exceſſive fatigue, which, whatever it may be called, produces exactly the ſame effect as accumulated excitability ariſing from any other cauſe. The waking ſtate is protracted, although no powerful ſtimuli are acting on the body, and ſleep may even be induced, by employing ſome of the more powerful ſtimulants; the effect of which, muſt ſurely be, to exhauſt the excitability. Here then is a caſe in which we ſhould have expected an exhauſted excitability. The continued action of the powerful agents, which produced exceſſive fatigue, as muſcular motion, mental energy, &c. we ſhould naturally have ſuppoſed, would have waſted the excitable principle, and have brought on rapidly the ſtate of ſleep. Such, indeed, is their effect, when acting in moderate proportion,—i. e. when acting in a certain proportion to the vigour of the animal organization. But when theſe powers act in a high degree, we find that they induce a modification of the animal fibre, which differs not in the leaſt from that which is produced by the abſtraction of ſtimuli, viz. a weakened ſtate of the organization, with all the phenomena of accumulated excitability. It muſt, however, be remarked, that in ſome inſtances in which the waking ſtate ſeems to be protracted by exceſſive fatigue, the operating cauſe is pain, ariſing from the violent or long-continued muſcular action: And it may be admitted, that in theſe caſes, ſleep is prevented by the operation of a powerful ſtimulus.

The ſecond cauſe which we have mentioned of morbid watchfulneſs, is the depreſſing paſſions, as fear, ſorrow, grief. The uniform effect of theſe powers upon the body, is to debilitate the organization. In no caſe do they produce energy in the ſyſtem; and we ſhould therefore be inclined to conſider them as direct ſedatives. We defer, however, the conſideration of their nature, till they come more particularly before us. But the effect of their operation is perfectly obvious. The animal fibre is enfeebled, and an accumulated excitability always attends their operation. The cauſe, then, of morbid watchfulneſs in both the caſes we have mentioned, is a debilitated organization, by which the body is rendered more ſuſceptible of the action of the various agents, than in the perfectly healthful ſtate. And to the ſame cauſe, we muſt aſcribe the watchfulneſs which attends many caſes of diſeaſe.

The partial interruption of reſt which we experience in dreaming, appears to ariſe from a greater or leſſer degree of debility in the organization. It is a fact univerſally known, that perſons under a great debility, are much more liable to dream, than thoſe of vigorous conſtitutions. Indeed, the ſleep of the former is generally a conſtant ſucceſſion of dreams. Thus, we obſerve, females, generally ſpeaking, are more ſubject to dream than males. In every inſtance, thoſe perſons who are much accuſtomed to dream, exhibit a debilitated organization, and a conſequent increaſed ſuſceptibility of the action of ſtimuli. In this weakened ſtate, the mental energy alone is commonly a ſufficient ſtimulus to produce dreaming, and the effect is proportionally increaſed, by the operation of the ſtronger paſſions of the mind. Material ſtimuli, as an overloaded or diſordered ſtomach, will produce the ſame effect, not only in debilitated habits, but proportionally in the more vigorous.

Somnambulancy appears to ariſe from the ſame cauſe, but operating to a greater extent than in ordinary dreams. In this diſeaſe, we perceive accumulated excitability ſtrongly marked. And to what cauſe can we aſſign the exceſs of this principle, unleſs to the enfeebled organization, which is conſtantly preſent.

Upon the whole, it appears that the vigour of the body is diminiſhed during the courſe of the day by the operation of the uſual agents; and if the debility induced is carried only to a certain extent, its ſuſceptibility of the action of theſe agents is alſo diminiſhed. In this caſe ſound or healthful ſleep ſucceeds: And after a certain period, the body, recruited by reſt, as well as the addition of new matter, reaſſumes its former vigour, and becomes again ſuſceptible of the action of the uſual ſtimuli. But if the degree of debility induced is conſiderable, whether cauſed by labour or diſeaſe, we find that the body retains its ſuſceptibility of the action of ſtimuli, and indeed exhibits all the phenomena of accumulated excitability. Theſe caſes of increaſed debility, by which the watchful ſtate is protracted, have been conſidered as inſtances of exhauſted excitability, or indirect debility. We have ſeen, that they are in fact attended with what is uſually termed accumulated excitability: But, as we have already ſaid, there appears to be no real difference in thoſe ſtates of the organization which have been diſtinguiſhed by the terms direct and indirect debility.

Various degrees, however, of excitability, or that ſuſceptibility which the animal body poſſeſſes of being excited to action by ſtimuli, appear not only in the different periods of human life, and in the alternation of the waking and ſleeping ſtates, they are alſo obſervable in an individual at any given period of life, or in two perſons at the ſame period. But in every inſtance theſe variations will be found to ariſe from ſome change taking place in the animal organization, by which, in a greater or leſſer degree, it has been debilitated, or received an acceſſion of ſtrength. We ſhall endeavour to illuſtrate the ſubject in this third point of view.

Let us here take for our example a perſon arrived at the age of manhood, and poſſeſſing a vigorous conſtitution; the various natural or healthful agents acting upon him, and employed in a due or moderate proportion: in this caſe we obſerve all the animal functions duly performed, and the vigour of the body carried to its utmoſt height. This is the higheſt ſtate of excitement of which the ſyſtem is capable; or, in other words, the organization is now in its moſt perfect ſtate. We may next conſider what will be the effects of abſtracting, or employing in too great proportion, the natural ſtimuli.

If the natural ſtimuli are abſtracted in any degree, a proportional degree of weakneſs will be produced in the ſyſtem. This is perfectly obvious, if the natural ſtimuli of heat or aliment are withdrawn in any conſiderable proportion. The organization is evidently debilitated:—The powers of life or excitement are diminiſhed; and, it would ſeem, the excitability is augmented in an equal ratio. That the powers of life are diminiſhed, will not be diſputed: And the ſeeming proportional increaſe of the excitability, appears to be proved by a great number of facts. If a perſon has faſted long, a ſmall proportion of any of the natural ſtimuli will produce a much greater effect upon the ſyſtem, than a larger quantity would have done if the body had not been debilitated by the abſtraction of the uſual ſtimuli. The ſtimulus then, in this caſe, ſeems to have a much greater effect than it would have had if ſimilar agents had been regularly applied to the body. Again, when the abſtraction of the uſual ſtimuli has been carried to a very conſiderable extent, as when a perſon is nearly famiſhed, a very ſmall proportion of a mild ſubſtance, as a few ſpoonfuls of broth, if haſtily ſwallowed, will produce the ſame effects as a ſtrong ſtimulant, ſuch as alcohol, would have done if the organization had not been thus debilitated. The mild ſtimulus will in this caſe produce the uſual exhilarating effects of ſpirituous liquors; and inſtances have even been known, in which a ſmall quantity of broth has produced death, in the ſame manner as a large quantity of alcohol would have done in a ſyſtem not debilitated by the abſtraction of the uſual ſtimuli. Theſe effects ſufficiently ſhow, that in that ſtate of weakneſs which is induced by the abſtraction of the neceſſary agents, the organization is more eaſily excited to action than in the healthful ſtate; and hence it has been ſuppoſed that the excitability is accumulated. It is, however, perfectly clear, that the abſtraction of one or more of the neceſſary or uſual ſtimuli, will produce a derangement of the organization, which is uniformly marked by debility. But the derangement to which the organization is liable, may be varied in ſeveral ways, according to the nature and uſe of the ſtimulus, and the proportion in which it is abſtracted, ſo as to produce, no doubt, ſeveral very different modifications of the animal fibre. The effects produced on the body by the abſtraction of different ſtimuli, we ſhall ſtate more particularly when treating upon the agents: at preſent it is ſufficient to obſerve, that by the abſtraction of aliment, the organization is debilitated, becauſe the animal fibre has not received that acceſſion of new matter which is neceſſary to preſerve it in the healthful ſtate. By the abſtraction of heat, i. e. when the body is placed in a low temperature, as at 32° or under, the animal heat is carried off in a greater proportion than that in which it is produced in the body; and the animal fibre, deprived of the neceſſary quantity of this ſtimulus, appears to be incapable of performing its uſual functions. Upon ſimilar principles, we may explain the cauſe of the derangement of the organization from the abſtraction of ſeveral other of the healthful agents. But it muſt be confeſſed, that the mode in which ſome of theſe agents operate, and by which they aſſiſt in preſerving the body in the healthful ſtate, have hitherto eluded the reſearches of all phyſiologiſts. The fact however is plain, that the abſtraction in any degree of all or any of thoſe powers which are neceſſary to the production and continuance of the phenomena of life, induces a debilitated organization; and the body thus weakened, appears to become more ſuſceptible of the action of theſe or other agents.

Upon the other hand, the organization of the ſame perſon, or of another of an equally vigorous conſtitution, may as eaſily be deranged by the ſame agents acting in too high a degree. Thus, too large a quantity of aliment will, in a certain period, produce debility. The ſame effect more rapidly follows too free a uſe of the artificial ſtimulants, as alcohol, or any ſubſtance containing it. And if the total abſtraction of the healthful agents will quickly annihilate the excitement, or deſtroy life; ſo alſo the ſame agents, operating in an extreme degree, and more eſpecially the artificial ſtimuli, will quickly ſo much derange the organization, that the animal functions can no longer be carried on.

There is, however, a material difference in the firſt effects produced on the body in theſe two caſes, although they both terminate by producing a debilitated organization, which ſeem in no reſpect to differ. A ſmall abſtraction of the natural agents produces a ſlow, and, perhaps, for ſome time, an almoſt imperceptible waſte of the ſyſtem; and the animal fibre is gradually debilitated. A ſmall increaſe beyond the due proportion of the healthful agents, or a moderate uſe of the artificial ſtimuli, cauſes, for a ſhort period, an increaſed vigour of body, and, in moſt inſtances, an increaſed acceſſion of matter to the ſyſtem. But if the practice is continued, and more eſpecially if the exceſs of ſtimulus is encreaſed, a debilitated organization infallibly enſues. In the final effects ariſing from theſe two oppoſite cauſes, we perceive no difference. By the firſt, debility may ſlowly commence, and gradually increaſe, in proportion to the degree in which the neceſſary agents are abſtracted, till, if not prevented by the proper remedies, the organization is totally deranged, and death follows: and during the progreſs of this debilitated ſtate, from the increaſed weakneſs, the body becomes daily more ſuſceptible of the action of ſtimuli. By the ſecond, a degree of vigour in the organization is certainly, in the firſt inſtance, produced: but by the continued action of too powerful ſtimuli, the organization becomes deranged, debility enſues, and the ſyſtem, as in the former caſe, becomes daily more ſuſceptible of the action of ſtimuli. The ſtates of direct and indirect debility, as they have been called, when the latter is fully eſtabliſhed, appear not to differ in their nature. And hence it ſeems a fair concluſion, that the method of cure, in both caſes, ought to be the ſame.

That the debility induced by the action

of too powerful ſtimuli, differs not from that which follows the abſtraction of the neceſſary agents, may be further proved, by the well-known effects of the more powerful artificial ſtimuli. We have already hinted at this, and may here farther obſerve, that we perceive no accumulation of the excitability when a perſon is indulging in ſtrong liquors even to intoxication. But no ſooner has the operation of the ſtimulant ceaſed, than we perceive a debilitated organization, in proportion to the exceſs in which the ſtimulus has been employed; and this debility is uniformly accompanied with a higher ſuſceptibility of the action of ſtimuli. It does not, therefore, ſeem true, in fact, that the debility which follows the exceſſive uſe of ſtimulants ariſes from an exhauſtion of the excitability: It is true, that an extreme doſe of alcohol or other ſtimulants will at once deſtroy the excitability and excitement; but the ſame effect will follow from the total abſtraction of the healthful agents. In almoſt all caſes the debility induced by the exceſſive action of ſtimuli, is certainly accompanied with a greater ſuſceptibility of the action even of the ſtimulant which has produced the debility. It muſt, however, be admitted, that opium furniſhes a contrary example: for as far, we believe, as obſervation has hitherto gone, it appears, that in the continued uſe of this drug, an increaſed doſe will always be neceſſary to produce the uſual degree of excitement. Yet even in this caſe it is certain, that a conſtitution debilitated by the uſe of opium, acquires an increaſed ſuſceptibility to the action of other ſtrong ſtimuli: And the only concluſion that we can rationally draw from the fact, that the doſe of opium muſt be perpetually increaſed, is, that various ſtimuli differ, not only in their degree, but alſo in their mode of operation.

We may now conclude this view of the principle of excitability with the following obſervations, which ſeem clearly to reſult from the facts already ſtated.

Firſt, The effects of ſtimuli upon the animal body, are, generally ſpeaking, in proportion to the vigour of the organization. Hence, in the middle period of life, the animal fibre can ſuſtain the action of thoſe ſtimuli which in childhood or old age would produce death.

Secondly, As the natural effect of all ſtimuli, and even of the mildeſt healthful agents, is ultimately to derange and debilitate the organization, it ſeems obvious that ſuch debility cannot be removed, but muſt be increaſed, by a free uſe of powerful ſtimulants. The natural method of removing debility, in every caſe, ſurely, is by employing in due proportion the neceſſary healthful agents, particularly aliment. The judgement of the practitioner ſhould be chiefly employed in the choice of the moſt nutritious and eaſily digeſted ſubſtances. The uſe of ſtrong ſtimulants, in a very moderate degree, is, no doubt, admiſſible; but their only uſe can be, to excite the action of the ſtomach and inteſtines, and to give a temporary vigour to the ſyſtem, which is favourable to the digeſtive proceſs. The opinion which has been held out, that the accumulated excitability, ſuppoſed to exiſt in caſes of direct debility, muſt be removed or waſted by the uſe of powerful ſtimulants, has led to an extremely dangerous practice. Can it be reaſonably ſuppoſed, that the extreme debility, which in many caſes is almoſt inſtantaneouſly produced by the contagion of typhus, is to be removed by ſuch a quantity of ſtrong ſtimulating liquors, opium, &c. as would exhauſt and debilitate the moſt vigorous conſtitution in the higheſt ſtate of health?

Thirdly, If an exceſſive uſe of powerful ſtimuli exhauſts the excitability, it would naturally follow, that in the cure of indirect debility all ſtimuli ſhould be withdrawn, except thoſe of the loweſt degree, that the diminiſhed excitability may again accumulate. Yet even here, the higheſt ſtimulus has in the firſt inſtance been propoſed, with the view, indeed,

deed, of gradually diminiſhing it. The total abſtraction of ſtrong ſtimuli may perhaps be improper: But certainly the uſe of that power, in the ſame, or nearly the ſame degree by which the diſeaſe was produced, can only augment the diſeaſe.

Fourthly, It has been very generally ſuppoſed, that the animal body is not only ſubject to diſeaſes of debility, but alſo to diſeaſes of over much ſtrength, or the ſthenic diathesis, as it has been termed; and this ſtate is ſaid to be produced by the uſe of various ſtimuli in too great a proportion. But as it is indiſputable, that all ſtimuli exhauſt and debilitate the organization, is it not to be ſuſpected that this diatheſis has no exiſtence in nature? For if debility immediately ſucceeds the operation of a powerful ſtimulus, how can the ſthenic diatheſis be ſuppoſed to exiſt after the ſtimulus has ceaſed to act? Beſides, it ſeems a little incongruous in language to call the higheſt ſtate of health a diſeaſe. Perhaps it would not be difficult to explain the nature of thoſe diſeaſes which have been ranked in this claſs upon very different principles, and to prove that they are the effect of a debilitated organization. But we leave the conſideration of this point at preſent, and only ſuggeſt, that at leaſt it deſerves ſome attention.

The modifications to which the animal organization is liable, and by which the excitability of the body appears to be increaſed or diminiſhed, and the powers of life or excitement rendered more or leſs vigorous or languid, are extremely various, nor is it perhaps poſſible to reduce them to general principles. Theſe effects evidently follow the action or abſtraction of the different agents we have already mentioned; and to a brief conſideration of which we now proceed, in the order formerly ſtated. In treating of theſe agents, we ſhall have occaſion to ſhow, that although the greater part of them undoubtedly poſſeſs a ſtimulant power, yet many, and perhaps all, operate alſo upon different principles, by which various alterations are produced in the animal fibre.

We begin with the conſideration of heat: and at preſent we confine ourſelves to external heat, or the effects produced upon the body by the temperature in which it is placed.

It is unneceſſary here to point out the nature or ſources of heat: nor ſhall we enter into any diſcuſſion of the queſtion, Whether heat is a ſpecies of matter really exiſting, or whether it is merely a modification of matter? There are ſufficient reaſons to induce us to aſſume the former opinion. From a variety of facts we can ſcarcely avoid concluding, that there exiſts in nature a ſpecies of matter *ſui generis*, and which appears to be a ſubtile elaſtic fluid, to the operation and various modifications of which we muſt aſcribe all the phenomena of heat. This fluid has received the diſtinctive name of caloric from the modern chemiſts.

That the operation of the caloric is eſſential to the production and continuance of life in all organized bodies, is too obvious to require particular proof. With reſpect to the human race, the range of temperature favourable to health is probably between the 32d and 80th degrees of the ſcale of Fahrenheit; and, generally ſpeaking, the middle point between theſe is the moſt favourable to health. But in proportion as the temperature recedes, i. e. if it ſinks below 32°, or riſes above 80°, it becomes injurious to health, and deſtructive to life. But by ſeveral wiſe proviſions in the œconomy of nature, and eſpecially from habit, individuals are enabled to bear conſiderable variations of temperature, without much injury.

As the temperature induced in the animal body, by the evolution of the caloric in the reſpiratory proceſs, is in the healthful ſtate from 96° to 100°; and as the medium which we inhabit is almoſt always below, and generally very much below that temperature; it is plain that we do not receive heat from the ſurrounding atmoſphere, nor from any other ſubſtance, unleſs it is of a higher temperature than our bodies: And as, to preſerve the healthful ſtate, it is not neceſſary that the temperature of the medium in which the body is placed ſhould be above 60°, it is plain that the animal body requires no additional ſupply of the caloric from external ſubſtances. Hence it follows, that the beneficial or injurious effects derived from the temperature of the atmoſphere, ariſe from the ſurrounding ſubſtances abſtracting in too great or too low a degree the caloric from the ſyſtem.

The operation of ſuch external heat upon the body is therefore only negative. But the viſible effects which variations of temperature produce upon all organized ſubſtances, compel us to include external heat in the liſt of agents which act upon the body. Theſe effects are obviouſly ſtimulating. Numberleſs facts ſupport this poſition. The diminiſhed temperature at the cloſe of autumn, and during winter, ſeems to extinguiſh life in almoſt all the vegetable kingdom. The cheering rays of the ſun in the returning ſpring re-excite the action of the vegetable fibre; the ſap riſes, and new parts are evolved. Something ſimilar to this is obſerved alſo in thoſe animals which remain in a torpid ſtate during winter, and which revive with the increaſed temperature of ſpring: And the experience of each individual of the human race, will ſufficiently teſtify the genial influence of heat in promoting action in the organization of the body. The experiments of Spalanzani ſhow that the action of the caloric is not only neceſſary to the production of life, but that the hatching proceſs may be accelerated by an increaſe of temperature within a certain degree. Thus the evolution of the tadpole from the ovum of the frog is haſtened by an increaſe of temperature. In like manner, the production of life in the chick *in ovo* is accelerated by placing the eggs in a temperature ſomewhat higher than that communicated by the parent animal.

Such however is the ſtructure of the animal organization, that to preſerve the vigorous and healthful ſtate, the caloric muſt be applied to it only in a certain proportion. There is, as we have already ſaid, a range of temperature favourable to life; and the middle point of this range, i. e. from 55° to 60°, ſeems moſt conducive to the vigour of the ſyſtem. The extremes of climate in the habitable world are equally unfavourable to the perfection of the animal, and to the healthy ſtate. At the medium temperature which we have mentioned, the ſurplus of that heat, which is perpetually evolving in the reſpiratory proceſs, is duly carried off; and there ſeems to be at this point a happy proportion eſtabliſhed between the action of the caloric and the animal fibre. But in proportion as the degree of temperature recedes from this point, we have reaſon to infer that it becomes injurious; becauſe debility is induced by the extremes of heat and cold. Now, if this effect follows either extreme, every degree of deviation from the middle point muſt be proportionally injurious. And injurious effects would certainly follow every deviation from this middle point, were it not for thoſe proviſions in the œconomy of nature at which we have already hinted, by which the human body can accommodate itſelf to a very extenſive range of temperature.

The effects of the caloric, however, are like thoſe of all other neceſſary ſtimuli: If acting in too great a proportion, debility ſucceeds; and if abſtracted in too great a degree, a weakened ſtate of the organization inevitably follows. The latter of theſe may be termed an accumulated, and the former an exhauſted excitability: But in fact we ſee no material difference in the ſtate of the organization produced in either caſe. Nay, preciſely the ſame effects will in ſome inſtances follow theſe oppoſite cauſes. A high temperature, or a very low one, will equally induce ſleep. This partial ſuſpenſion of the animal functions ſeems plainly to indicate a diminution of the excitability; and when this ſtate is produced by the ſtimulus of heat, we ſhould perhaps be in no ſuſpence to ſay, that the excitability was exhauſted by the action of the caloric. But muſt we not, upon the ſame principles, infer, that the excitability is exhauſted when ſleep is induced by too great an abſtraction of heat? we are however rather diſpoſed to conclude, that a debilitated ſtate of the organization is in both caſes induced, which differs not in its nature, and can only be removed by the ſame means, viz. the body being gradually reſtored to a medium temperature.

It is well known, that the continued abſtraction of heat in the high northern latitudes, concurring with other cauſes, conſiderably accelerates the production of that ſtate of debility which conſtitutes ſcurvy. In like manner, the exceſſive action of the caloric in the torrid zone, aſſiſted no doubt by other cauſes, produces diſeaſes of debility, which differ indeed in their form, but perhaps not much in their nature, from thoſe which follow the abſtraction of heat. It is equally well known, that either the exceſſive action, or the abſtraction of the caloric, will facilitate the formation of typhus fever. From this ſimilarity of effects we cannot, with any propriety, infer an exhauſtion of the excitability by the exceſſive action, or an accumulated excitability by the abſtraction of the caloric; but we clearly perceive a debilitated organization ariſing from both cauſes, and which, we are diſpoſed to think, can only be removed, under all its various forms, by nearly the ſame means.

From this general view of the effects of external heat upon the animal body, we ſhould be inclined to ſuppoſe that the caloric is a ſimple ſtimulant, i. e. that it does not, like aliment, communicate new matter to the ſyſtem, but operates upon the animal fibre merely by its ſtimulant quality. But upon a ſubject of this kind it is neceſſary to ſpeak with caution. We are little acquainted with many of the operations which take place in the animal œconomy. We cannot ſay what modifications the caloric may undergo in the body, or into what new combinations it may enter,

enter. There are many reaſons which may induce us to believe that the caloric received into the body enters into chemical combination with other matters, ſo as to be changed into the latent ſtate or combined caloric of the modern chemiſts. Hence it may be ſuppoſed to form a conſtituent of the body; and in that caſe, even this apparently ſimple ſtimulus will afford an additional proof, that the different agents which operate upon organized bodies, do not act merely as ſtimuli.

It is probable that the phenomena of light are produced by a modification of the caloric. This therefore appears to be the moſt proper place to introduce a few obſervations on the effects of light upon organized matter. Light indeed does not appear eſſentially neceſſary to the production or continuance of animal or vegetable life; for we find that the vegetating proceſs may be carried on, and animal life is preſerved in the healthy ſtate, although light is wholly abſtracted. Yet this ſubſtance is one of the common agents, which act, generally ſpeaking, upon all the individuals of the animal and vegetable kingdoms. But we are perhaps leſs acquainted with the effects produced by light, than thoſe almoſt of any other agent.

With regard to the vegetable kingdom, it is clear that the colour, odour, taſte, and combuſtibility, are to be attributed in a great meaſure to the action of light. Theſe qualities generally depend on the preſence of volatile oils: And we find, that vegetables, which are natives of the warmer climates, and which conſequently enjoy a greater proportion of light than thoſe of other regions, poſſeſs theſe qualities in the higheſt degree. It is certain, then, that plants undergo very conſiderable alterations with reſpect to their conſtituents, in proportion to the degree in which they are expoſed to the operation of light.

The effects of light upon animals are by no means ſo obvious as upon vegetables: Yet we obſerve, that even the colour of animals is in ſome degree affected by the operation of this fluid. Animals wholly deprived of light are changed to white. Such is the effect produced on the hair of animals during the long night of the arctic circle. A ſimilar effect has alſo been obſerved upon thoſe animals of other regions which, during a part of the year, ſeclude themſelves from the light. Generally ſpeaking, the colour of the human race varies, from jet black to the faireſt complexion, in proportion as they are expoſed, in a greater or leſſer degree, to the action of light. Other cauſes may probably alſo contribute in producing all the different ſhades of colour, from that of the Negro to the Briton or the Dane; but the operation of light cannot be excluded. It is probable therefore that the conſtituents of animal bodies, as well as thoſe of vegetables, are varied by the agency of light.

In conſequence of its phyſical properties, light has a very conſiderable effect upon mankind. By producing the phenomena of viſion, it becomes an agent for communicating a great variety of ideas to the mental faculty. It may from hence be the means of awaking either the agreeable or depreſſing paſſions: But theſe effects are rather to be aſcribed to the object which the light preſents to the mind, than to the operation of light itſelf.

The ſimple operation of light upon organic matter appears to be that of a mild and agreeable ſtimulant. Hence the pleaſing ſenſation, the cheerfulneſs of ſpirit, which every one experiences from the ſtrong ſolar light of a fine day. It may indeed be ſuppoſed, that heat alſo aſſiſts in producing that hilarity we feel in fine weather: and, in ſome meaſure, perhaps this is true. But every one almoſt is ſenſible of a ſuperior degree of cheerfulneſs under a clear ſky, in the coldeſt day, above that induced by a warmer temperature, when the hemiſphere is clouded. A ſimilar effect is alſo produced in a certain degree by a ſtrong artificial light, ſuch as the ſplendid illuminations of a theatre or a ball-room.

The ſtimulating quality of light is principally ſeen from its effects upon the eye;

and in the operation of light upon this organ, we may trace all the uſual effects of ſtimuli. If totally abſtracted, the ſight becomes weak; an apparent increaſe of excitability ſeems to be preſent; for the eye cannot bear the action of a ſtrong light. But by the power of habit, as is the caſe with other ſtimuli, the organ becomes leſs ſenſible of the operation of this agent. Thus, as we have formerly hinted, perſons who have accuſtomed themſelves to exclude the light from their chambers, cannot ſleep if it is admitted, although the ſyſtem has undergone the uſual exhauſtion from the labours of the day. Others, again, fall into the ſtate of ſleep notwithſtanding light is preſent, provided they have habituated themſelves to its action during the period of ſleep. The former alſo do not find ſleep prevented by the admiſſion of light, if they have been more than ordinarily exhauſted by exerciſe. To perſons whoſe eyes are weak, the ſtimulus of light is often extremely injurious. Its action, when extreme, like that of other ſtimulants, will totally derange the organization. Thus blindneſs has frequently been induced by the long-continued action of a ſtrong ſolar light.

Actual obſervation, as well as analogy, ſhows that a certain proportion of light is neceſſary for the animal œconomy. The increaſed or diminiſhed action of this fluid, does not indeed produce injurious effects equal to thoſe which follow the abſtraction, or extreme action, of ſome other ſtimulants: but we find the total abſtraction of light produces a debilitated organization, both in animals and vegetables; and the deſtruction of the power of viſion is the moſt violent effect of the extreme action of this agent: yet its operation is not ſolely confined to the organ of viſion, but, as we have already ſaid, it is alſo capable of varying and modifying the conſtituents of bodies. In ſhort, light appears to be a powerful agent, which, by its ſtimulant property, produces a variety of changes upon organic matter. If its operation is not abſolutely eſſential to the production and continuance of life, yet its preſence is actually neceſſary to effect a variety of purpoſes in the œconomy of nature, by which life is rendered much more agreeable than it could have been without this agent.

The third agent, to the conſideration of which we proceed, is Air. It is a general fact, that air is neceſſary for the production and continuance of life in all organized ſubſtances, whether animal or vegetable. Neither animal nor vegetable life, therefore, can be preſerved long *in vacuo*; but it is a recent diſcovery, which we owe to modern chemiſtry, that it is oxygenous gas, one of the conſtituents of atmoſpheric air, which is alone ſo peculiarly important to the animal œconomy.

Atmoſpheric air appears to be formed of two conſtituents of very diſſimilar properties, the azotic and oxygenous gaſes. The baſes of theſe two gaſes, viz. azote and oxygene, enter into the compoſition of animal and vegetable ſubſtances. By a variety of operations, which it would be improper for us here to detail, we can ſeparate the oxygene from atmoſpheric air; and we can obtain, from a great number of other ſubſtances, both the azotic and the oxygenous gaſes. In atmoſpheric air the proportions are ſeventy-two of azotic, and twenty-eight of oxygenous gas.

It is now well known, that combuſtion is ſupported by the oxygenous part alone of atmoſpheric air; or, more ſtrictly ſpeaking, that combuſtion conſiſts in the union of oxygene with the ſubſtance burnt. Different ſpecies of matter, therefore, are more or leſs inflammable, in proportion to their affinity with oxygene. Animal reſpiration appears to be a proceſs extremely analogous to combuſtion. The ſame change is produced upon the air during reſpiration, as in the combuſtion of carbonaceous matter.

For the performance of the important function of reſpiration, nature has ſupplied the human race with an organ of the moſt curious ſtructure, in every part of which we ſee the moſt ſtriking proofs of wiſdom in the contrivance. It is unneceſſary here to enter into a minute deſcription of the various methods employed in the ſtructure of the lungs, by which the introduction and expulſion of the air is facilitated,—by which the air is brought in contact with the numerous ramifications of the arteria pulmonis,—and by which all the purpoſes of reſpiration are effected. It is ſufficient to obſerve, that the ſubſtance of the lungs is formed of a vaſt number of membranous cells, and of three kinds of veſſels, to which we may add nerves. The whole of theſe veſſels and nerves are interſperſed among the cells, forming innumerable ramifications. The veſſels of the lungs are, the bronchia, or air-veſſels,—the pulmonary arteries and veins,—the bronchial arteries and veins,—and the lymphatics.

From experiments which can eaſily be performed on the human race, as well as other animals, it appears that thoſe ſpecies which are provided with lungs reſpire only in conſequence of the oxygenous gas contained in atmoſpheric air; and the function of reſpiration is exerciſed with greater vigour, in proportion to the quantity of oxygenous gas contained in the air reſpired. Any other gaſeous fluid, in which there is none of this pure air, is totally unfit for reſpiration, and will in a longer or ſhorter period deſtroy life, in proportion to the nature of the gas, and the ſtrength and habits of the animal which reſpires it.

During the reſpiration of atmoſpheric air, two very important circumſtances are obſervable. Firſt, A quantity of air diſappears; and ſecondly, The air which is expired differs materially from that which was inſpired. Both of theſe circumſtances are to be accounted for from the ſame cauſe,—the change which takes place in the air during reſpiration. The atmoſpheric air which we inhale, is a mixture, as we have already ſaid, of ſeventy-two parts of azotic, and twenty-eight of oxygenous gas. The air which is expired, when reduced to the temperature of the atmoſphere, is conſiderably diminiſhed in bulk; and it is now found to conſiſt of the azotic, carbonic acid, and oxygenous gaſes. The azotic gas of atmoſpheric air is returned, in expiration, undiminiſhed in quantity, and unchanged in quality: a conſiderable proportion of the oxygenous gas has diſappeared, and a quantity of the carbonic acid gas is found, which was not preſent in the air which was inſpired.

Upon the whole it appears, that during reſpiration no alteration takes place upon the azotic gas contained in atmoſpheric air; it is expelled in the ſame ſtate and quantity in which it was received. A conſiderable proportion of the oxygenous part of the air diſappears, and a large quantity of the carbonic acid gas is produced. From hence we may conclude, that a proceſs preciſely ſimilar to combuſtion takes place, either in the reſpiratory organ, or throughout the animal body. The carbonic acid gas is beyond diſpute, a product of combuſtion. Now, the diſappearance of the oxygenous, and the evolution of the carbonic acid gas, can only be accounted for upon one or other of the following principles: Firſt, It may be ſuppoſed, that a ſlow combuſtion of carbonaceous matter takes place on the internal ſurface of the lungs, by which the whole of the oxygenous gas which diſappears, is changed into the ſtate of carbonic acid gas; or ſecondly, Perhaps the oxygenous gas which diſappears, is abſorbed, and conveyed into the circulating fluids, and during the courſe of circulation is united with carbonaceous matter, forming the carbonic acid gas, and which is exhaled from the lungs during reſpiration. Before we attempt to give any determination upon this ſubject, it is neceſſary to conſider what effects are produced on the blood by the reſpiratory function. Theſe are chiefly two; firſt, the colour of the blood is changed; and ſecondly, heat is evolved. It has long been known, that the arterial blood poſſeſſes a bright vermilion colour, and that the venous is much darker, in ſome caſes approaching nearly to blackneſs. Now, it is obſerved, that the dark-coloured venous blood, tranſmitted by the arteria pulmonis, undergoes a conſiderable change in its colour when in the lungs; ſo that the blood which is returned by the pulmonary veins poſſeſſes a bright vermilion hue. A ſimilar effect is produced upon the venous blood when expoſed to atmoſpheric air. After it has ſtood for a while, we obſerve it to acquire a more florid colour. This effect is produced with more rapidity, if the venous blood is placed in contact with oxygenous gas: The vermilion colour is quickly induced; and a ſimilar change is produced on the air placed in contact with it, to that which takes place during reſpiration, that is, the bulk of the air is diminiſhed, and a quantity of carbonic acid gas is formed.

Now, as the colour of the blood returned to the heart by the pulmonary veins has acquired the vermilion hue, it is natural to ſuppoſe, that the whole change produced upon the blood by the oxygene is effected in the lungs. Yet when we conſider, that if blood is placed in contact with atmoſpheric air, or oxygenous gas, even out of the body, the ſame effect is produced, it remains doubtful whether this change ſolely takes place in the lungs, or whether oxygenous gas is not abſorbed in the lungs, and conveyed into the circulating fluids, and ſo produces this change of colour, by uniting with carbonaceous matter in every part of the arterial ſyſtem.

The ſecond effect produced during reſpiration, is the evolution of heat. The cauſe of animal heat has in all ages attracted the attention of philoſophers; and many theories have been formed to account for this phenomenon of the animal œconomy, the moſt of which ſeem merely hypothetical. The firſt philoſopher who paved the way for the development of this important ſubject, was the celebrated Dr Black. He firſt attributed the production of animal heat to the proceſs of reſpiration.

The ſame theory was further illuſtrated, and in ſome degree modified, by Dr Crawford, in his treatiſe on animal heat. Much light has alſo been thrown upon this ſubject by the diſcoveries of many of the modern chemiſts. We ſhall not however narrate the gradual progreſſion by which this theory has arrived at that degree of perfection in which we now find it. Nor is it neceſſary to enter into any particular illuſtration of the doctrine. It is ſufficient to obſerve, firſt, That in reſpiration a quantity of oxygenous gas diſappears, and a portion of the carbonic acid gas is produced. It follows then, ſecondly, That reſpiration is a proceſs perfectly analogous to combuſtion; and thirdly, That during the tranſmutation of the oxygenous into the carbonic acid gas, a conſiderable quantity of the caloric muſt neceſſarily be evolved.

When we conſider the large quantity of oxygenous gas which diſappears during reſpiration, and the great difference in the relative capacities of the oxygenous and carbonic acid gaſes for receiving heat, we ſee, in the reſpiratory proceſs, a cauſe abundantly ſufficient for the production of animal heat. And as this cauſe is perpetually operating, there would be a ſurplus of heat produced in the animal ſyſtem, were it not perpetually going off to the ſurrounding bodies.

Now in this method of accounting for the production of animal heat, it is not material whether we ſuppoſe that the tranſmutation of oxygenous into carbonic acid gas takes place in the lungs, or whether the oxygenous gas is abſorbed in the lungs, and mixed with the maſs of circulating fluids. In the latter caſe, we muſt ſuppoſe that the oxygenous is changed into the carbonic acid gas in every part of the arterial ſyſtem, and that the carbonic acid gas is thrown out from the circulating fluids during their paſſage through the lungs. In either caſe, however, the effect is the ſame. Oxygene ſeparated from the reſpired air, unites with carbonaceous matter in the lungs, or in every part of the arterial ſyſtem; and the caloric muſt in either caſe be evolved.

We may now briefly ſtate the effects produced in the animal œconomy by the proceſs of reſpiration. The firſt, as we have obſerved, is, producing a change in the colour of the blood during its paſſage through the lungs. The change of colour is produced by the ſeparation of carbonaceous matter from the blood. This ſeparation is proved by the formation of carbonic acid gas in the lungs. Thus far the proceſs of reſpiration is perfectly analogous to combuſtion. Whether any portion of the oxygene, which diſappears in reſpiration, is united to the blood, ſeems at leaſt to be doubtful. But it is evident, that the blood has undergone a very conſiderable change in its appearance and qualities. The florid colour, and the peculiar qualities which it has acquired in the lungs, is in a greater or leſſer degree preſerved through the arterial ſyſtem, but are entirely loſt in its progreſs through the venous ſyſtem. There can ſcarcely be any doubt, that the qualities acquired by the blood during its paſſage through the lungs, render it a more powerful ſtimulus to the heart and arteries, ſo as to be more capable of exciting their contraction. But the proofs of this point we muſt defer, till we conſider the action of the circulating fluids as an exciting power.

The ſecond uſe of air in reſpiration, is the production of animal heat. The evolution of the caloric in the lungs, is a conſequence which muſt unavoidably follow the proceſs which takes place in that organ, viz. the production of the carbonic acid gas. The heat of animals is uniformly found to be in proportion to the ſize of the lungs, the capacity of this organ for performing its functions, and the nature of the air which is reſpired. The lungs therefore muſt be conſidered as a focus of heat, from which the whole ſyſtem is ſupplied. 'In proportion to the ſize of the lungs, a greater or leſſer quantity of oxygenous gas is changed into the ſtate of carbonic acid gas. If the lungs are in an unhealthy ſtate, as in an aſthma, this change takes place only in a ſmall degree, and a proportionally leſs quantity of the caloric is evolved. There are however other caſes of diſeaſe, as in phthiſis pulmonalis, in which there ſeems to be an increaſed action of the lungs, by which a larger proportion of carbonaceous matter is ſeparated from the blood. That ſuch an effect takes place, ſeems to be proved by the very florid colour even of the venous blood in this diſeaſe; and alſo by the increaſed heat which is preſent in the ſyſtem. It is remarkable, that theſe effects are produced, even after a conſiderable portion of the ſubſtance of the lungs has been deſtroyed by the diſeaſe *.

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* Whether any advantages will be derived from cauſing patients labouring under theſe, or other diſeaſes, to reſpire air modified by the mixture of different gaſes, is to me exceedingly problematical. It would however be premature to give any opinion upon this ſubject, becauſe experiments are yet wanting to determine whether beneficial or injurious effects will reſult from the practice. It is to be wiſhed that Dr Beddoes may ſucceed in the attempt in which he is at preſent engaged, of forming an eſtabliſhment

The heat thus evolved in the proceſs of reſpiration is one of the moſt important agents in producing and continuing the phenomena of life. We have already proved, that the operation of heat is indiſputably ſtimulant: and it only remains here to obſerve, that the heat neceſſary for animal life is evidently produced by the reſpiratory function. It appears that the temperature of animal bodies cannot be conſiderably increaſed or diminiſhed by external cauſes, unleſs theſe cauſes operate in extreme degrees, as appears by the experiments of Drs Fordyce and Blagden *.

In taking an accurate view of the operation of oxygene in reſpiration, three effects appear to be produced, which are immediately neceſſary for the continuance of animal life. First, A quantity of carbonaceous

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ment for applying the gaſes in different diſeaſes with that accuracy, and in ſuch quantities, as may afford a perfect deciſion with reſpect to the propriety of the practice.

* *Vid.* Philoſophical Tranſactions, Vol. LXV.

bonaceous matter is ſeparated from the blood. This is ſufficiently evidenced by the production and expulſion of the carbonic acid gas. As a quantity of carbonaceous matter is expelled during reſpiration, we muſt conclude that the retention of this matter would have been injurious to the ſyſtem. We cannot however ſuppoſe, that the mere retention of a ſmall portion of carbone is the immediate cauſe of that ſudden ceſſation of the powers of life, which is produced by the total abſtraction of oxygene for a very ſhort period.

The ſecond effect of oxygene in reſpiration, is the evolution of heat. This is alſo equally eſſential to animal exiſtence: for if heat is not produced in a due proportion, undoubtedly diſeaſe will follow. It does not however appear that ſudden death by the abſtraction of oxygene, is cauſed by a diminution of ſenſible heat in the animal body; but this effect of reſpiration, the evolution of heat, muſt be conſidered as of the higheſt importance to the animal œconomy.

The third effect of oxygene in reſpiration, is the change produced on the arterial blood. That a very important alteration is produced in the colour and qualities of the blood during its paſſage thro' the lungs, and that this alteration is in ſome way produced by the oxygene which diſappears during reſpiration, is fully proved by experiment, and is indeed univerſally allowed. The blood, by this change in its qualities, appears to become a proper ſtimulus for exciting the action of the heart and arterial ſyſtem. This, we apprehend, may be proved, from a clear induction of facts, which we ſhall have a more proper opportunity of introducing when treating on the ſtimulant power of blood. If, however, this change in the qualities of the blood is not perpetually effecting in the lungs, the powers of life will be quickly ſuſpended. If oxygenous gas is wholly abſtracted from any animal, the firſt effect which follows is an impeded circulation, and quickly the heart and arteries ceaſe to beat. The powers of life are then entirely ſuſpended. With the greateſt probability, we may attribute the ſudden ceſſation of life, during the abſtraction of oxygene, to the blood being no longer a proper ſtimulus for exciting the action of the heart and arteries; and this evidently ariſes from the uſual change not taking place in it by the reſpiratory function.

It appears then, from the effects of oxygenous gas in reſpiration, that it cannot be conſidered merely as a ſimple ſtimulus to the body; nay, its operation ſeems chiefly to depend upon its chemical qualities. Whether oxygene, during reſpiration, is or is not received into the circulating fluids, ſo as to become an actual conſtituent of the body, certainly has not been decided; but it is plain, that in either caſe, oxygenous gas produces a very material change in the ſtate and qualities of the blood, by which that fluid is fitted to act as a proper ſtimulus to the animal fibre of the heart and arteries. The oxygenous gas, therefore, operates in this caſe as a chemical agent; and there can be little doubt, that by the alteration which is thus induced in the ſtate of the blood, an equally material change is produced in the animal fibre, which receives its nutrition from the blood. We have therefore, in oxygenous gas, another example of a natural or healthful ſtimulus, which acts upon the animal body, not only by its ſtimulant power, but alſo by its other qualities. It is equally clear, that oxygenous gas differs from many other ſtimuli, not only in the degree of its power, but alſo in the nature of its operation.

Before we entirely quit the conſideration of the effects of air as a ſtimulant to the animal ſyſtem, it ſeems proper to add a few obſervations upon the nature and effects of ſound. We ſhall therefore introduce this as the fourth natural agent or ſtimulus. The operation of ſound, as we have already obſerved, is not abſolutely neceſſary, either to the production or continuance of animal life. Of this we have daily an opportunity of obſerving a clear proof, in many of our ſpecies who are not poſſeſſed of the power of hearing: yet it is equally clear, that excepting in theſe few inſtances, ſound is an agent capable of producing the moſt powerful effects upon the animal body; and in the human ſpecies we often witneſs its operation in a great variety of modes. Though it is not abſolutely eſſential to the production or continuance of life, it is at leaſt of conſiderable importance, and is capable of being employed as one of the artificial ſtimuli, by which very conſiderable alterations may be produced in the ſtate of the human ſyſtem.

Sound, by whatever ſubſtance produced, appears to be received and transferred only by thoſe ſubſtances, the parts of which are capable of being eaſily moved, ſo as to change their relative ſituations. But ſome ſubſtance is abſolutely neceſſary to convey ſound, becauſe we find it is utterly loſt in vacuo, and it is increaſed in proportion to the denſity of the air. Elaſtic fluids form the moſt common, and perhaps the moſt convenient medium for transferring ſounds. At one time it was ſuppoſed that ſound was conveyed by air alone. The ingenious Profeſſor of Anatomy in this Univerſity has however ſhowed, in his treatiſe on the Phyſiology of Fiſhes, that ſound is alſo conveyed by water, and nearly with as much rapidity as by the atmoſphere. Other inelaſtic fluids muſt alſo be able, in certain degrees, to produce the ſame effect.

To form ſound, the motion or colliſion of bodies is requiſite. By this motion or colliſion, a tremor or vibration is induced in the transferring medium. There is an evident impulſe on the medium through which ſound is conveyed, produced by the motion or colliſion of bodies. This impulſe is ſuppoſed to produce certain oſcillations in the air, or any other medium capable of conveying ſound, by which its plane ſurface is alternately elevated and depreſſed into the form of arches or curves, ſo as to form a ſucceſſion of ſonorous waves. The impulſe received by the transferring medium, is by it conveyed to the organ of hearing. Hence we may fairly conclude, that the ſenſation received from ſound in the ſenſorium commune is produced by an actual impulſe on the external organ of hearing. That the ſenſation which we call ſound, is produced by an impulſe on the ſentient extremity of the auditory nerve, may be further ſupported from other phenomena of ſound. The oſcillations of the air produced by the motion or colliſion of bodies, ſucceed each other with a certain velocity, proportioned to the force of the motion or colliſion: And it appears, that to produce an audible ſound, at leaſt thirty of theſe oſcillations muſt be produced in a ſecond of time. Now, it ſeems clear, that in proportion as the vibrations in the transferring medium are, in a given time, few or many, the impulſe on the organ of hearing will be ſtrong or weak. When the vibrations are few, the impulſe upon the organ of hearing is ſo faint, as to be imperceptible.

As the ſenſation of ſound appears to be produced by a direct impulſe, we have reaſon to conclude that it operates upon animal bodies by a ſtimulant power.

The operation of ſound is chiefly obſerved in effects produced upon the mental powers. Sound, however, may be employed, and it may produce on the mental faculty the moſt powerful effects, while yet thoſe effects are not to be aſcribed to the ſound itſelf, but to that which is expreſſed by it. Thus ſounds expreſſed by the human voice may be employed in the delivery of hiſtoric facts,—the narration of a tale of woe,—in deſcribing a comic ſcene,—or upon any other ſubject which may excite emotions in the human mind: pity, grief, or horror may be awakened;—mirth, joy, eſteem, love, or admiration may be excited; yet the producing of theſe emotions is not wholly to be aſcribed to the ſounds which have been employed, becauſe, had the ſame facts and circumſtances been ſubmitted to the eye in reading, the ſame paſſions would have been excited in minds poſſeſſed of ſenſibility. It is true, the effect of eloquence depends in a great meaſure on muſic; for, in the large and proper ſenſe of the word, muſic has been ſtyled, the art of variouſly affecting the mind by the power of ſound. The moſt illiterate and vulgar minds are in ſome meaſure capable of feeling the power of a juſtly modulated voice, riſing or falling by ſucceſſive harmonious notes, and changing to various keys, as the ſubject may require. The whole effect of oratory, however, is not to be aſcribed to the powers of the ſpeaker; the influence of the matter delivered, muſt be diſtinguiſhed from that of the manner in which it is pronounced. In eſtimating, therefore, the power of ſound in oratory upon the human mind, we muſt deduct a conſiderable ſhare as properly belonging to the ſubject, and not to the ſounds by which it is expreſſed. In the mere enunciation of facts by the human voice, in the ordinary occurrences of life, the mental powers are frequently affected in a high degree. But here the influential power is not the ſound of the voice, but the fact announced. It is by the power of ſound, unaccompanied by human language, that we muſt endeavour to appreciate the influence of this ſtimulus upon the mental power of man. In the effect of muſic, we have an opportunity of obſerving its full force.

Particular combinations of ſound ſeem naturally to inſpire joy; others have an equal effect in producing melancholy; in ſhort, every paſſion and emotion of the mind may be produced by proper combinations of muſical notes. Theſe effects take place in conſequence of an impulſe upon the organ of hearing, by thoſe oſcillations of the air which are produced by a muſical inſtrument. The auditory nerve in this caſe is evidently the immediate organ of ſenſation; and it is equally clear, that by this impulſe ſome modification, though altogether unknown to us, muſt take place in the ſentient organ, by which the peculiar ideas expreſſed by the muſical ſounds are awakened in the mind.

But is the operation of ſound in all caſes the ſame? Does every poſſible combination of ſound ſtimulate the ſyſtem? Or does not ſound in many caſes produce a directly ſedative effect? In many inſtances, it undoubtedly ſtimulates the ſyſtem, and ſeems even to produce a temporary vigour. Thus, a perſon fatigued by labour is excited to dance by hearing a joyous tune, with which, by habit, he has aſſociated the idea of dancing. The impreſſion is here firſt on the mental power, and the energy of the mind induces the motion of the body. If a perſon in theſe circumſtances feels not that laſſitude which he had juſt before experienced, and which is really the caſe, the temporary vigour he enjoys muſt ultimately be aſcribed to the operation of ſound, as the original exciting power. The depreſſing paſſions, however, are equally produced by the action of ſound.

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When theſe operate, we ſee not the leaſt increaſe of excitement; nay, the ſyſtem paſſes from the ſtate of vigour to that of debility. And if we cannot conceive any power to be ſtimulant, excepting it excites the ſyſtem, at leaſt in the firſt ſtage of its action; we ſurely cannot reaſonably conclude, that thoſe combinations of ſound which produce the depreſſing paſſions ſtimulate the ſyſtem. It may, indeed, be alledged, that the ſounds which ſeem naturally adapted to expreſs grief or ſorrow, operate preciſely in the ſame manner upon the organ of hearing, by the impulſe of certain undulations induced in the air, as the ſounds which are expreſſive of joy; and that if one impreſſion conveyed by theſe undulations is ſtimulant, ſo alſo muſt the reſt. To this we would anſwer, that we cannot with preciſion eſtimate the *modus operandi* of any ſubſtance on the ſyſtem, merely from a knowledge of the medium through which it operates: It is only by the effects which we obſerve to be produced, that we can form any juſt determination

termination relative to the power of any particular ſubſtance upon the ſyſtem. In proceeding, according to this method, by induction, we ſtand upon firm ground. We are too little acquainted with the nature and properties of every ſubſtance, to be able *a priori* to ſay what will be their effects upon the animal body; nor will even a knowledge of their ſenſible qualities, in every caſe afford us any conſiderable aſſiſtance. Reaſoning, then, from the various effects produced upon the human ſyſtem by different combinations of ſound, we muſt conclude, that their modes of operation are totally diſſimilar, notwithſtanding that they operate through the ſame medium.

Sound then appears to be an agent capable of acting upon the animal frame, and of producing material changes in the ſtate of its organization, although it neither adds new matter to, nor abſtracts any from the body. It operates directly upon the animal fibre. The ſenſations which it produces are tranſmitted to the mental power, and this laſt, by its reaction upon the animal body, produces a vigorous or debilitated ſtate of the organization. It is obvious, therefore, that although ſound is capable of exciting the ſyſtem to action, yet it is an agent in many reſpects different in its nature from any of the preceding.

The fifth, and laſt, of the external powers which operate upon the body, is aliment. Under this term is included a great variety of ſubſtances, many of which ſeem to poſſeſs very diſſimilar qualities. Alimentary matters have generally been divided into food, condiment, and drink. Food and drink muſt be reckoned among thoſe powers, the operation of which is eſſential to the production and continuance of animal life. The wants of nature in this reſpect are indeed few, and eaſily gratified; but the caprice and luxury of man have increaſed the liſt of alimentary matters to an enormous ſize. Many ſubſtances which have been employed as food, cannot be conſidered as favourable

vourable to health. The liſt of condiments alſo contains many others that are evidently pernicious; and perhaps ſeveral of the fluids employed as drink are equally, if not more injurious. The modifications of alimentary matters by the art of cookery, alſo not unfrequently produce the moſt pernicious effects. We would not however, with ſtoical apathy, reject any wholeſome or agreeable article of food, merely becauſe nature can be ſupported without it: nor can we condemn any method by which a common article of diet is rendered more agreeable to the palate, for no better reaſon, than that life may be ſupported without the taſte being in this manner gratified. By following the dictates of nature, and availing ourſelves of experience, we may eaſily avoid employing any ſubſtance which is injurious to health. Yet it ſeems extremely difficult to point out the nature and properties of the different articles of food and drink, together with their effects upon the human body; nor does it appear that this ſubject has yet been treated upon fully or properly. The limits, however, which we have preſcribed in this eſſay, will not permit us at preſent to attempt a particular elucidation of this ſubject.

It is obvious, that alimentary matters are chiefly deſigned to repair the waſte of the ſyſtem, and that they are in fact the principal ſource from which the body derives new matter. Hence, although they are all undoubtedly ſtimulating, yet they cannot be ſuppoſed to act upon the body merely by their ſtimulant power. We ſhall endeavour to illuſtrate this by a brief view of the digeſtive proceſs, which appears to be conducted in a great meaſure upon chemical principles. It muſt however be admitted, that food of every kind is capable of acting upon the organization by its ſtimulant power, independent of its uſe as furniſhing new matter to the body. Thus water, which is perhaps the weakeſt ſtimulant employed as drink, is capable of exerting a ſtimulant operation even upon thoſe who are accuſtomed to employ much more powerful fluid ſtimuli. Water is extremely beneficial in reſtoring a perſon under deliquium animi. The ſtimulating effect of food and drink is obvious to the feelings of every perſon. After long abſtinence or fatigue, we find the body inſtantaneouſly invigorated on receiving a ſmall portion of the mildeſt alimentary matter. Now, in this caſe, no part of the ſubſtance received into the ſtomach, whether ſolid or fluid, has been abſorbed by the lacteals, and mixed with the circulating fluids. We can therefore only account for the effect on the ſuppoſition, that the matter employed ſtimulates the animal fibre of the ſtomach; and as the body is an indiviſible whole, the operation is inſtantaneouſly extended to the moſt diſtant parts.

The principal benefit, however, derived from the aliment, is the new matter which it affords the ſyſtem. The alteration which the food undergoes, and by which a proper nutritious matter is extracted from it, appears to be produced both on mechanical and chemical principles. The food is firſt mechanically divided, and mixed with the ſaliva, in the proceſs of maſtication. It is next tranſmitted to the ſtomach; and here probably it is in a ſmall degree ſubjected to mechanical action, by the gentle alternate motions of the orbicular fibres of the muſcular coat. It does not however appear, that the muſcular action of the ſtomach aſſiſts in the digeſtive proceſs. The operation in this viſcus ſeems rather to be conducted upon chemical principles; and the chief uſe of what has been called the periſtaltic motion of the ſtomach, appears to be, to propel the aliment, when ſufficiently digeſted, through the pylorus.

In man, and all other animals, a fluid is ſecreted in the ſtomach, which appears in the different orders to vary in its quality. It is ſuited to the nature of the food which they are deſtined to employ; and the gaſtric fluid in each ſpecies appears capable of diſſolving that kind of food which nature has provided for them. The gaſtric fluid of carnivorous animals eaſily diſſolves animal food, but has little effect on vegetable matters;—that of the ruminating animals readily diſſolves vegetable ſubſtances, but ſcarcely produces any change upon animal matters;—while that of the human ſtomach is capable of diſſolving, nearly with equal eaſe, both animal and vegetable ſubſtances.

It has been fully proved, by the experiments of Stevens, Spalanzani, and others, that the gaſtric fluid in man, and other animals, is capable of reducing the alimentary matters into a ſoft maſs or pulp, independent of any degree of trituration, in the ſtomach; becauſe food incloſed in ſpheres and tubes, formed of metal or of wood, and by which the food was conſequently defended from trituration, has been completely diſſolved: And the ſame effect has been produced by the gaſtric fluid upon alimentary matters, even out of the body.

Powerful however as the ſolvent operation of the gaſtric fluid ſeems to be, it is incapable of acting upon the living animal body. We do not perceive any material difference between a piece of raw fleſh recently cut from an animal, and the ſame ſubſtance in the living ſtate; yet the gaſtric fluid eaſily diſſolves the former, while it does not in the leaſt act upon the latter, otherwiſe it would diſſolve the ſtomach in which it is ſecreted. But no ſooner has that degree of derangement taken place in the organization of any animal, by which it is rendered incapable of the action of the life-ſupporting powers, than it becomes ſuſceptible of the action of the gaſtric fluid. That ſtate of the organization which is neceſſary for life, is capable of reſiſting the operation of this fluid: and hence it is, as Mr John Hunter has remarked, that we find animals living in the ſtomach, or even hatched or bred there; but the moment that life is ſuſpended in any of theſe, they become ſubject to the ſolvent power of the gaſtric fluid. We are certainly not poſſeſſed of any facts which enable us to point out the cauſe why animal matter, in the living ſtate, is capable of reſiſting the action of this fluid, when it ſo eaſily diſſolves the ſame ſubſtance immediately after death.

But the ſaliva, and the ſuccus gaſtricus, are not the only fluids which are employed in the digeſtive proceſs. During its progreſs through the inteſtines, the alimentary matter is mixed with the bile and the pancreatic juice. From the nature of the former, we are certain that its operation is in a conſiderable degree chemical: but it muſt be confeſſed, that we are too little acquainted with the nature and operation of the whole of theſe fluids, to point out, with any degree of accuracy, their preciſe effects, in extracting from the aliment a proper nutritious matter for the ſupport of the body. In general, we perceive, that decompoſitions are effected, both in the aliment, and the animal fluids employed in the digeſtive proceſs; and conſequently various new combinations muſt be formed. The chemical nature of the digeſtive proceſs, together with the other leading fact, that the aliment affords new matter to the ſyſtem, furniſh the moſt deciſive proof, that aliment does not act merely as a ſtimulant to the body.

It will be here underſtood, that we readily admit, that proper alimentary matter poſſeſſes a ſtimulant power in a greater or leſſer degree. In what we mean further to offer upon this ſubject, we ſhall therefore confine ourſelves to ſome general obſervations on the nature of aliment, in two points of view: Firſt, As poſſeſſing ſtimulant powers, differing from each other, perhaps in nature, and certainly in degree; and ſecondly, As furniſhing nutritious matter to the ſyſtem.

Were we particularly to inveſtigate the qualities and effects of the different articles of aliment, it would probably appear that ſome of thoſe ſubſtances poſſeſs a conſiderable ſtimulant power, by which the action of the ſtomach is exerted, while they contain but a ſmall proportion of nutrition; and, on the contrary, other ſubſtances may contain a large portion of nutritious matter, which poſſeſs a low ſtimulant power: Yet it muſt be confeſſed, that it is not poſſible to aſcertain the degree of ſtimulus in any ſubſtance merely from its ſenſible qualities. Acrimony, perfectly obvious, is not always a proof, that the ſubſtance in which it is found will more highly ſtimulate the ſyſtem than other ſubſtances, the ſenſible qualities of which are comparatively mild. Were we to judge merely from the ſenſible qualities, we ſhould conclude, that ſeveral of the acrid oils, as the eſſential oils of mint, cinnamon, and others, were higher ſtimuli than alcohol, or even opium. Experience, however, proves the contrary. Theſe examples are taken indeed from the artificial ſtimuli; but perhaps varieties ſomewhat analogous to them, may be found among the ſubſtances which we employ as articles of food. It does not ſeem poſſible, therefore, to eſtimate the degree of ſtimulant power in any ſubſtance, excepting from the effects which we perceive it to produce in the animal œconomy. Again, another difficulty ariſes on this ſubject. A particular ſubſtance may actually poſſeſs a conſiderable degree of ſtimulus, and when firſt introduced into the ſtomach, may, in ſome meaſure, excite that viſcus to action; but it is immediately mixed with the ſuccus gaſtricus, and perhaps with other ſubſtances,—it undergoes a kind of decompoſition, and new combinations are formed, which probably poſſeſs qualities exceedingly different from thoſe of the ſtimulating ſubſtance received into the ſtomach. This, in many inſtances, muſt be the caſe; becauſe, as we have already obſerved, the digeſtive proceſs is, in a great meaſure, ſtrictly chemical. In the new combinations which are formed, there may be different degrees of ſtimulus, by which not only the action of the ſtomach and bowels may be excited, but alſo the matter which is abſorbed by the lacteals may poſſeſs different qualities in this reſpect; and hence the blood may become a more or leſs powerful ſtimulus to the ſanguiferous ſyſtem. That ſuch alterations in the quality of the circulating fluids may take place, cannot be denied, although alterations in the nature of the blood have not hitherto been particularly attended to; excepting in a few diſeaſes, where the change upon this fluid is exceedingly great and obvious.

There are again other ſubſtances which may be received into the ſtomach,—tranſmitted to the inteſtines,—abſorbed by the lacteals,—and mixed with the circulating fluids, without undergoing any change in the whole of this proceſs. Of theſe we have a remarkable inſtance in the ſolid colouring matter of the rubia tinctorum, which is not only conveyed into the blood, but depoſited in the bones, without having undergone any alteration. Sulphuric æther may alſo be mentioned as an example of a powerful ſtimulant being received into the circulating fluids, without undergoing any material change. It is a well-known fact, that vapours of this ſubſtance are in ſome caſes thrown out of the body with the expired air, for thirty or forty hours after receiving a large doſe. The juices alſo of ſeveral vegetable ſubſtances, which are employed as articles of diet, or at leaſt as condiment, ſeem to undergo little change in the digeſtive proceſs, of which raw onions and garlick are ſtriking examples.

From theſe obſervations two concluſions are obvious; Firſt, That it is extremely difficult to aſcertain the degree of ſtimulus which many ſubſtances exert on the fibre of the ſtomach and alimentary canal; becauſe it appears, that in various inſtances the degree of ſtimulus cannot be determined by the ſenſible qualities; and it is equally impoſſible, in many caſes, to aſcertain what degree of ſtimulant power is poſſeſſed by the new compound formed in the digeſtive proceſs. Secondly, It appears, that thoſe ſubſtances which are moſt eaſily digeſted, do not, in many caſes at leaſt, poſſeſs ſo high a ſtimulant power as the more indigeſtible. Digeſtion, ſtrictly ſpeaking, is the change of certain principles contained in the alimentary matters, into proper chyle, fit for the nutrition of the ſyſtem. We clearly ſee, that ſome of the moſt powerful ſtimulants that are ever received into the ſtomach, and which are commonly employed as drink, condiment, or medicine, do not undergo this change, or at leaſt the alteration which takes place in them is only partial. From hence, then, we cannot infer, that thoſe animal and vegetable ſubſtances which experience ſhews to be the moſt proper and nutritious aliment, are the moſt eaſily digeſted, or the moſt highly ſtimulant: We muſt rather, and with more reaſon, conclude, that thoſe which are eaſily digeſted poſſeſs a degree of ſtimulus more exactly ſuited to the ſtate of the organization or excitability in the fibre of the ſtomach, than the more indigeſtible; while theſe latter poſſeſs either too high or too low a ſtimulant power.

It muſt, however, be again remarked, that a mere ſtimulating quality, capable of exciting the fibre of the ſtomach, in whatever degree it may exiſt in the alimentary matter, is not ſufficient to account for the digeſtive proceſs, nor can the degree of ſuch a mere ſtimulant power be the chief cauſe why one ſubſtance is more eaſily digeſted than another. For, if it is true that the ſolution of alimentary matters by the ſuccus gaſtricus is effected upon chemical principles, it will follow, that the peculiar qualities of this fluid are of much greater importance in the digeſtive proceſs, than the degree of ſtimulus poſſeſſed by the aliment. For it is certain, that the ſuccus gaſtricus is capable of diſſolving the aliment, independent of any action in the animal ſolid. It may be indeed alledged, that of two given ſubſtances the one may be more eaſily digeſted than the other, becauſe that which is moſt eaſily diſſolved poſſeſſes a degree of ſtimulus to excite the action of thoſe veſſels in which the gaſtric juice is ſecreted; and that the ſubſtance which is not ſo eaſily digeſted, does not poſſeſs a ſufficient degree of ſtimulus to produce this effect.

We may readily admit, that the aliment may ſtimulate the veſſels on the ſurface of the ſtomach, upon principles merely mechanical. Upon ſuch principles, it is evident, that the ſaliva is excreted in larger quantity during maſtication than at other times; but this reaſoning, however plauſible, certainly does not apply in all caſes, in explaining why one ſubſtance is more eaſily diſſolved in the ſtomach than another; becauſe, if different ſpecies of aliment, as we have formerly obſerved, are incloſed in ſpheres or tubes, the gaſtric fluid is found to act more powerfully upon ſome than others. In the ſtomachs of carnivorous animals, vegetable matters are ſcarcely acted upon; — in the merely herbiverous, animal matters are not diſſolved; — and in man, the degrees of ſolution in different ſubſtances exceedingly vary. Now, in all theſe caſes, the mechanical action, applied to the ſurface of the ſtomach by the tubes or balls, is preciſely the ſame: beſides, as we have ſaid, the gaſtric fluid extracted from the body and placed *in vitro*, exhibits the ſame variety of effects upon different ſubſtances. And, in this caſe, the action of the gaſtric fluid is not aſſiſted by that of any ſtimulant power, whether mechanical, or of any other kind. The ſecretion of a proper fluid to effect the ſolution of the alimentary matter, depends on the proper ſtate of the circulating fluids from which the gaſtric liquor is ſecreted, and the ſtate of the ſecreting organs; and both of theſe muſt ultimately depend on a due degree of excitement being maintained in the ſyſtem at large; and this can only be effected by the natural agents or exciting powers being employed in a due proportion, by which the organization is preſerved in the healthy ſtate. The gaſtric fluid, however, being thus properly formed and ſecreted in due proportion, its action on the alimentary matter is, as we have ſaid, ſtrictly chemical. Hence then it is clear, that we cannot aſcribe the peculiar ſolubility of any ſubſtance in the ſtomach to its poſſeſſing a high degree of ſtimulant power; nor in any great meaſure to the degree of ſtimulus which it poſſeſſes, but rather to the quality of the gaſtric fluid, and to the quantity of the alimentary matter being juſtly proportioned to the quantity of the ſolvent fluid which the ſtomach is able to furniſh.

It may be objected, that the appetite is increaſed, and the digeſtion promoted, by throwing into the ſtomach highly ſtimulating ſubſtances, as alcohol in various forms, and certain vegetable ſtimulants, as water-creſſes, horſe-radiſh, muſtard, and others; to which may be added the whole liſt of ſtimulating ſubſtances employed in cookery, and eſpecially in the formation of ſauces. It muſt here be obſerved, that the operation of ſubſtances by which the appetite ſeems to be increaſed, cannot all be accounted for upon the ſame principles. A conſiderable number of ſubſtances in the liſt of condiments, and the peculiar modes of preparing food, by rendering the alimentary matter more agreeable to the taſte, are in many inſtances the cauſe of our employing a larger quantity of food than we otherwiſe ſhould do. In other caſes it may be admitted, that highly ſtimulating ſubſtances may excite the action of the ſtomach, ſo as to enable us to receive a greater quantity of food than uſual. But it may be juſtly doubted, whether the digeſtive power is in any caſe much increaſed by the uſe of ſuch ſtimulants. Nor can it be ſuppoſed that the digeſtive power can be promoted by their uſe, excepting the excretion of the gaſtric fluid is increaſed by their ſtimulant action. But here it muſt be alſo obſerved, that not only, as we ſhall preſently ſhow, their producing this effect is in many inſtances dubious, but alſo, if the effect is produced, the continued uſe of ſuch ſtimulants muſt be extremely injurious. For it is not to be ſuppoſed that the ſyſtem can, in a limited period, ſupply any given quantity of the gaſtric fluid. And the forcing out of the veſſels an improperly prepared fluid, can never be ſuppoſed to increaſe the digeſtive power. Their continued uſe, therefore, can only induce a general debility of the ſyſtem. Within certain bounds, they may indeed be employed, without very obviouſly producing injurious effects. But when uſed in large quantity, and the practice perſiſted in, indigeſtion, and all the other effects of repletion, inevitably follow. Beſides, the ſeeming appetite which is ſuddenly produced by mixing ſtimulating ſubſtances with our food, is not wholly to be aſcribed to the excretion of a greater quantity than uſual of the gaſtric fluid. For not only are we induced to ſwallow a large quantity of particular ſubſtances, from the taſte being gratified, but powerful ſtimulants, by exciting the mere muſcular contraction of the ſtomach, may force a quantity of the aliment through the pyloric orifice into the inteſtines, without having undergone that change which is neceſſary to the preparation of proper chyle. It may be readily admitted, that when the ſyſtem is under debility, and the ſtomach and bowels are particularly

larly affected, as in dyſpepſia, and other analogous caſes, the uſe of ſtimulants of various kinds, provided the degree of ſtimulus is properly proportioned, may excite a due action in theſe organs, and promote the excretion of ſuch a quantity of the gaſtric juice as may effect the digeſtion of the food, the formation of a proper chyle, and conſequently the removal of the general debility, by furniſhing a ſufficient quantity of nutritious matter to the ſyſtem. But there is reaſon to ſuſpect, that in theſe diſeaſes too great a quantity of the more powerful ſtimuli is not unfrequently employed.

From the whole of theſe obſervations, the following concluſions may be fairly drawn. Firſt, That the digeſtive proceſs does not ſolely depend upon the ſtimulating power of the alimentary matter, but alſo on the relation ſubſiſting in the laws of nature between various ſubſtances, and by which they are diſpoſed to enter into chemical combination. Secondly, Excluding from our conſideration the mechanical ſtimulus of the aliment, ariſing from its bulk, or degree of conſiſtence, we do not perceive that the ſtimulant power poſſeſſed by any ſubſtance can be determined merely by its ſenſible qualities out of the body. Therefore, thirdly, The degree of ſtimulus poſſeſſed by any given ſubſtance can only be determined by the effects which we obſerve it to produce on the body. And, fourthly, That in eſtimating the qualities of any ſubſtance as an alimentary matter, we can only aſcribe to its ſtimulant power the property of accelerating the digeſtive proceſs in a certain degree, and upon the principles already ſtated: excepting in the caſe of thoſe ſtimulants which do not undergo any change in this proceſs, and which may be abſorbed by the lacteals in a mere ſtate of mixture with other matters. But an inſtance of theſe laſt is perhaps not to be found among proper alimentary ſubſtances.

We go on, in the next place, to offer ſome general obſervations upon the ſecond mode in which alimentary matters act in the animal body: that is, as furniſhing a proper nutritious matter to repair the waſte which takes place in conſequence of the various excretions. Upon this point, the firſt queſtion that occurs is, What is the proper nutritious matter? If this queſtion were clearly ſolved, it might perhaps ſeem eaſy to determine, in the ſecond place, what ſpecies, or individuals, among the various kinds of aliment, furniſh the moſt proper or the largeſt quantity of nutritious matter. There are difficulties, however, which cannot be eaſily overcome, attending the ſolution of both theſe queſtions.

With reſpect to the firſt, What is the proper nutritious matter? The late ingenious Profeſſor Cullen has endeavoured to prove, that it is formed of the acid, oil and ſaccharine matter which we find, in the more or leſs combined ſtate, in vegetables. Obſerving that the greater number of animals which are employed as aliment derive their whole ſupport from vegetable matters, he conſidered it as reaſonable to conclude, that the proper nutritious matter was ultimately to be ſought for in the vegetable kingdom. As an acid is found in many vegetable ſubſtances which are employed as aliment;—as ſaccharine matter is either originally preſent, or may, by certain proceſſes, be evolved in the moſt nutritious vegetable matters; —and as an oil is very generally preſent, or may be extracted from the moſt of theſe;—he concluded that they together formed the proper nutriment of animal bodies. To theſe he was inclined alſo to add, the vegeto-animal gluten which Beccaria had diſcovered in a conſiderable number of vegetables, and which eſpecially abounds in ſome of the moſt nutritious, as in wheat. This, as a ſubſtance exceedingly analogous to animal matters, or rather as being always found in animal bodies, may with ſome reaſon be conſidered as proper nutriment. But Dr Cullen further obſerving, that acids, oils, and ſaccharine matter, are never found in the ſeparate ſtate in the blood, or other animal fluids, at leaſt when in health; he therefore concluded, that the chyle was formed by an intimate mixture of theſe principles. Now, although this theory cannot be admitted, and eſpecially in that latitude to which Dr Cullen ſeems to have extended it; yet juſtice compels us to obſerve, that it had a conſiderable degree of plauſibility at the time when it was formed, and that it was offered with that modeſty and diffidence which always mark true genius. We may even go farther, and admit, that in ſome inſtances, particular mixtures, formed of two or more of theſe ſubſtances, may be received into the ſanguiferous ſyſtem. But a more accurate chemiſtry, and a more rigid analyſis of both animal and vegetable matters, than was known at the time when Dr Cullen wrote, lead us in ſome reſpects to ſpeak with more certainty, and in others with a greater degree of heſitation, concerning the forms of thoſe ſubſtances which are extracted from animal and vegetable matters to ſupply the body with nutrition.

We find, that the principal conſtituents of animal and vegetable ſubſtances, are different combinations, in various proportions, of carbone, hydrogene, oxygene, and azote; the laſt being generally in a greater proportion in animals than in vegetables. The whole of theſe are indeed found in the acid, oil, ſugar, and vegeto-animal gluten which Dr Cullen ſuppoſed formed the nutrition of animals; yet we cannot ſay that a mere mixture of theſe forms the chyle, becauſe in that decompoſition which takes place in the alimentary matters when mixed with the gaſtric fluid, it is impoſſible to determine what new combinations are formed. Nor is it reaſonable to ſuppoſe that nothing more is effected in this wonderful proceſs than the formation of a mere emulſion, by the mixture of an acid, an oil, ſaccharine matter, and a portion of vegeto-animal gluten. Beſides, there are other parts of vegetable ſubſtances which may furniſh ſeveral of the conſtituents of animal bodies, as well as the previouſly formed acid, oil, or ſaccharine matter. Nor are we certain that thoſe conſtituents of animal bodies which we obtain as the laſt reſult of analyſis, are themſelves ſtrictly ſimple. It has been alledged, that carbone is a compound ſubſtance, formed of hydrogene and azote. This, though perhaps not fully proved, is at leaſt poſſible. And the ſame may be the caſe with ſeveral others, which, in the preſent ſtate of our knowledge, are neceſſarily conſidered as ſimple bodies. Hence various decompoſitions and new combinations may be formed in the digeſtive proceſs, with which we are totally unacquainted. There are alſo other ſubſtances beſide thoſe which we have juſt mentioned, which muſt be conſidered as conſtituent principles of animal bodies: As the phoſphate of lime, which forms ſo conſiderable a proportion of the bones; iron, and ſeveral ſaline matters, which are uniformly found in the fluids. Now the whole of theſe are either received into the body ready formed, or they are produced in the ſyſtem by the combination of their various conſtituents. To take, for the illuſtration of this ſubject, the phoſphate of lime for our example. From the great quantity of this ſubſtance in the bones, a conſiderable proportion of which we know is daily carried off by excretion, it is clear that a daily ſupply of it is required; and either the ſubſtance already formed, or its conſtituents, are introduced into the ſyſtem, and are a part of the true nutritious matter. Now the phoſphate of lime may be received into the body already formed: Yet we do not perceive any ſource from which in this ſtate it can be derived. It exiſts, indeed, both in animal and vegetable matters. But it is in a very ſmall proportion in vegetables; and the quantity is alſo exceedingly minute in thoſe parts of animal bodies which we employ as aliment. In fact, it is only found in conſiderable quantity in the bones. It is equally certain, that neither this compound ſalt, nor any of its conſtitu-

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ents, as far as we know, excepting oxygene, are contained in the vegetable acids, oils, ſaccharine matter, or vegeto-animal gluten, in which Dr Cullen ſuppoſed he had found the whole of the nutriment, or conſtituent principles of animal bodies. We are almoſt reduced to the concluſion, that the phoſphate of lime is formed in the animal ſyſtem. And admitting this, we are ſtill involved in the greateſt difficulty, in order to account for the introduction of its principles into the body. The phoſphoric acid, one of its conſtituents, abounds in the animal ſyſtem. It is found in the urine, and other fluids, united with different baſes, as ſoda, ammoniac, and lime. It is alſo found in the diſengaged ſtate, its preſence having been frequently detected in the ſtomach. This circumſtance of the uncombined phoſphoric acid being found in the body, ſeems to warrant the concluſion, that it received its origin as an acid there. But in this caſe, we are totally at a loſs to account for the introduction of the phoſphorus,

rus, from which it muſt be produced, unleſs it may be ſuppoſed that phoſphorus itſelf is not a ſimple ſubſtance, but formed of conſtituents with which we are yet unacquainted. We are equally at a loſs to account for the introduction into the ſyſtem, of the lime, the baſis of this ſalt; becauſe we do not conceive that it can be found in ſuch quantity in any alimentary matter, as to produce ſo large a portion as muſt be daily forming in the ſyſtem, the quantity of which we can in ſome degree eſtimate, from our knowledge of the quantity daily carried off in the excretions. With reſpect to the iron that is found in all the red-blooded animals, and in a very great proportion of vegetables, it is now a very generally-received opinion among chemiſts, that it derives its origin from the vegetating and animalizing proceſſes. Of the ſaline matters, it is highly probable that the ammoniac is formed in the animal ſyſtem. Mankind indeed may receive a ſmall quantity of this ſalt in the juices of other animal matters. But the greater proportion of the ammoniacal ſalt contained in the animal matters which we employ as aliment, muſt be either decompoſed or ſeparated in the various methods of preparing our food. That a conſiderable quantity of ammoniac muſt therefore be continually forming in the animal ſyſtem, ſeems clear; and this muſt more eſpecially be the caſe in thoſe of the inferior orders, which are wholly nouriſhed by vegetable matters. There is alſo ſome reaſon to ſuſpect, as we have formerly hinted, that ſoda is formed in the animal ſyſtem. We find it united with oil and mucus in the bile, and it is alſo found in ſome other of the animal fluids. Nor can we ſuppoſe that this alkali is furniſhed by the muriate of ſoda, which we employ as a condiment, becauſe it is alſo found in the bile and other fluids of various animals, who never receive any of the muriate of ſoda. We muſt therefore conclude, that this ſalt alſo is formed by the animalizing proceſs.

In attempting to account for the manner in which the daily waſte of the ſyſtem is ſupplied by new matter, we muſt not wholly confine ourſelves to the digeſtive proceſs. In treating upon reſpiration, we have obſerved, that it is doubtful whether one of the conſtituents of the body, viz. oxygene, is not received during the reſpiratory proceſs. And it has never been determined, whether particular ſubſtances may not be inhaled by the abſorbent veſſels on the ſurface of the body. In diabetes, it is generally admitted, that a very conſiderable abſorption takes place by theſe veſſels. This, indeed, conſtitutes diſeaſe. But it is not unreaſonable from hence to infer, that in the healthy ſtate an abſorption may alſo be continually going on, and by which the body may be ſupplied with ſome of its conſtituents. This ſuggeſtion may in ſome degree be ſupported by analogy, drawn from the vegetable kingdom. It is very generally ſuppoſed, that vegetables receive a conſiderable part of their nutrition from the atmoſphere by abſorption.

From theſe obſervations, the difficulties attending the ſolution of the queſtions which we have ſtated, are ſufficiently obvious. When we find that the changes which take place upon the alimentary matters are ſo great and various; and that theſe changes are not only produced in the digeſtive proceſs, but alſo in the blood, and perhaps in many of the ſecreting organs; we muſt conclude, that it is almoſt impoſſible to point out the particular parts of any animal or vegetable ſubſtance, from any mode of examining the conſtituents of that ſubſtance, or the conſtituents of the animal body which is nouriſhed by it. It is, indeed, natural to ſuppoſe, that animal ſubſtances will furniſh a greater quantity of nutritious matter than vegetables; and that it will be more eaſily aſſimilated to the animal body, becauſe it approaches ſo nearly in its nature to that body which it is employed to ſupport. But if we had no other evidence that animal matters are more capable than vegetables of furniſhing nutrition, than merely the ſimilarity of the animal matter to the body which receives it, we ſhould have little reaſon to draw ſuch a concluſion: Firſt, Becauſe death has induced a very conſiderable change upon the animal matter which we employ as aliment; and, *a priori*, it is impoſſible to determine how great the difference may be between living and dead animal matter. Secondly, The animal aliment undergoes another and equally important change, by the various modes of cookery to which it is ſubjected. And thirdly, Animal, as well as vegetable matters, appear to undergo a total decompoſition in the digeſtive proceſs. From theſe facts it is clear, that if we had no other evidence on the point, we could not determine, that of equal quantities of animal and vegetable ſubſtances, the one would furniſh more nutritious matter than the other. Both animal and vegetable ſubſtances contain, though in different proportions, the conſtituents of animal bodies. From ſimply conſidering their nature or their differences, as animal and vegetable matters, we ſee no reaſon why the nutrition proper for man might not be extracted from the one in as large a quantity as from the other, or why the one ſhould be more eaſily aſſimilated to the animal body than the other. The conſtituents of an ox do not materially differ from thoſe of man: Yet we ſee the former animal may be ſupported and fatted wholly with graſs, a vegetable which will afford very little nutrition to man. By other modes of evidence we perceive, indeed, that animal ſubſtances contain a greater quantity of nutritious matter, and are more eaſily aſſimilated than vegetables. If equal quantities of any animal, and the moſt nutritious vegetable ſubſtance, are received into the ſtomach, the perſon employing them will derive, *cæteris paribus*, a greater degree of ſtrength and vigour from the uſe of the animal than the vegetable matter. Here the proof depends upon a ſimple and obvious fact. Upon the ſame principles we may in ſome meaſure aſcertain the different proportions of nutritious matter furniſhed by the various animal and vegetable ſubſtances which are employed as articles of diet. And as in every inſtance it will be found that animal matters give a greater degree of ſtrength and vigour to the ſyſtem than vegetables, we may juſtly conclude, that animal matters contain a greater proportion of proper nutrition than vegetable ſubſtances. It may however be queſtioned, whether a larger proportion of vegetable matters, eſpecially of the more nutritious, will not communicate as great a degree of vigour to the ſyſtem as a ſmaller quantity of animal food, and particularly to perſons who are habituated to its uſe. With ſome reſtrictions, this queſtion ſhould probably be anſwered in the affirmative. Animal matters, however, do not only contain a greater proportion of nutritious matter, but they are alſo more eaſily aſſimilated to the animal ſyſtem. The proof of this is drawn from the various ſtructure which obtains in the inteſtines of the carnivorous and phytovorous animals. In the carnivorous animals we find only one ſtomach, and the inteſtines are comparatively ſhort. The phytiverous are frequently ſupplied with two or more ſtomachs, and the inteſtines are extended to a great length. It is evident from theſe varieties in the ſtructure of the alimentary canal, in animals which are deſtined reſpectively to live on theſe different ſpecies of aliment, that animal matters are digeſted in a ſhorter period than vegetables. The inteſtines in man are of a medium proportion between thoſe of the merely herbiverous and carnivorous animals: And this ſtructure indicates, along with other facts, that nature has deſigned both animal and vegetable matters to be employed as the aliment of mankind. It ought however to be remarked, that other reaſons have been aſſigned, beſide this that we have juſt mentioned, for the peculiarities in the ſtructure of the inteſtines of thoſe animals which reſpectively live upon animal and vegetable diet. It has been ſuppoſed, that the ſhortneſs in the one caſe, and the length in the other, are deſigned to counteract certain inconveniencies which attend the fæces produced from theſe different kinds of aliment. In particular, as the fæces in man and the carnivorous animals are extremely fœtid, it is ſuppoſed that they have ſo great a tendency to putrefaction, that it would be extremely inconvenient if they were long retained in the body. Hence a ſhort inteſtine is provided, to facilitate their expulſion. On the other hand, as a vegetable diet has a conſiderable tendency to produce laxity, perhaps from various cauſes, it is alledged, that the length of the inteſtines in phytovorous animals is deſigned to prevent the alimentary matters from being too rapidly carried off, and conſequently to allow a ſufficient period for the ſeparation and abſorption of the nutritious matter. Allowing theſe arguments their full force, we may alſo reaſonably admit, that the length of the inteſtines in different animals is alſo proportioned to the eaſy or difficult aſſimilation of the aliment which they are deſigned to employ.

In attempting, then, to aſcertain what particular parts of any ſubſtance are extracted as nutritious matter, we find ourſelves totally at a loſs. We obſerve, that a chemical decompoſition of the alimentary matters takes place, and that new combinations are formed in the ſtomach by the agency of the gaſtric and other fluids. When the aliment is propelled into the inteſtines, it undergoes a farther change, by being mixed with the bile, and the other fluids which are there ſecreted. New combinations are alſo there formed, with the nature of which we are by no means acquainted. After theſe alterations have taken place, the chyle is extracted from the general maſs, and abſorbed by the lacteals; and with reſpect to the nature of this fluid, we poſſeſs ſcarcely any information. When the chyle is mixed with the blood, it is deſtined to undergo other modifications, of the nature of which, and the mode of operation by which theſe alterations are produced, we are entirely ignorant. Beſide all this, various alterations are taking place in the different ſecreting organs; and, as we have recently obſerved, a number of ſubſtances, ſome of which are known to be compounds, and others which at preſent are conſidered as ſimple bodies, appear to receive their origin by unknown operations carried on in the animal œconomy.

On a ſubject ſo completely involved in obſcurity, there is abundant room for forming hypotheſes. But as from theſe no poſſible benefit can reſult, I ſhall decline the taſk. We have dwelt thus long upon this ſubject, to ſhew the inſuperable difficulties under which, in the preſent ſtate of our knowledge, it labours. With reſpect to the firſt queſtion, What is the proper nutritious matter by which animal bodies are ſupported? we muſt content ourſelves with obſerving, that the various conſtituents, of which animal bodies are formed, are extracted from the alimentary matters, and, by the different ſtages of the animalizing proceſs, already mentioned are applied to their various uſes in the body. In ſome caſes, perhaps, they may be received in a compound ſtate, and may in that form be proper for immediate application as a part of the ſyſtem. In other caſes, and which perhaps are the moſt frequent, they are reduced to more ſimple principles, and enter into new combinations, before they become a part of the animal body to which they are aſſimilated. With regard to the ſecond queſtion, What ſpecies or individuals among the various kinds of aliment, furniſh the moſt proper, or the largeſt quantity of nutritious matter? It appears that we have no data by which to decide, excepting the obvious facts, that one ſubſtance is more eaſily digeſted, and communicates a greater and more laſting vigour to the ſyſtem, than another. And the knowledge of theſe facts can only be derived from obſervation and experience.

Having thus briefly conſidered the nature and effects of the external agents, the action of which appear neceſſary to the production and continuance of life, we proceed to take a ſhort view of thoſe internal powers which operate upon the organization, and by which the phenomena of life are ſupported.

Of the internal agents, we firſt take notice of the blood. This ſubſtance, which forms the general maſs of the circulating fluids, appears chiefly deſtined to ſerve two offices in the ſyſtem. Firſt, To induce a farther change upon the chyle, or nutritious matter received from the aliment; and in the courſe of the circulation, to depoſite this new matter in every part of the body, to repair the waſte which the ſyſtem is perpetually ſuffering, and to furniſh matter for the ſecretion of various fluids neceſſary to the animal œconomy, ſuch as the bile,—the ſuccus gaſtricus—the ſaliva, &c. Secondly, To ſtimulate the heart and arteries, by which they are excited to action; and hence the circulation is produced.

The conſtituents of this fluid in the healthy ſtate have of late years been aſcertained with conſiderable accuracy; yet we cannot ſay that much information has been derived from theſe inquiries, with reſpect to the fitneſs of the blood for either of the two purpoſes we have mentioned. The coagulable lymph, or fibre of the blood, ſeems not to differ in its nature and qualities from the matter of the muſcular fibre. Hence we may conclude, that it is a ſubſtance prepared in the ſanguiferous ſyſtem, to ſupply the waſte of the animal fibre. With reſpect to ſome other parts, it is not eaſy to determine, whether they are deſigned to be depoſited in any part the body, or whether they have not already been employed, and are to be conſidered as excrementitious, and intended to be carried off in the urine and perſpirable matter. Such, for example, are the ſaline matters which are found in the blood; as the muriate of ſoda, and the phoſphates of ſoda, ammoniac, and lime.

But without entering further into conſiderations of this kind, it is ſufficient here to ſhow, that the blood does in fact effect the purpoſes we have mentioned. With reſpect to the firſt, it is univerſally admitted, and we need not therefore enter upon any particular proof; it will be ſufficient to obſerve, that the ſtate of the organization will be liable to conſiderable variations, in proportion to the quantity and quality of the nutritious matter contained in the blood. The formation of a proper nutritious matter muſt neceſſarily depend on the previous ſtate of the organization, together with the quality of the ingeſta. The due ſecretion of the gaſtric and other fluids employed in digeſtion, the formation of a proper chyle, and the further animalizing proceſs which takes place in the ſanguiferous ſyſtem, muſt depend on the ſtate of the ſolids. Hence any attempt to reſtore a debilitated ſyſtem muſt be in vain, unleſs we can, by nutritious matters, reproduce a healthy ſtate of the organization.

With reſpect to the ſecond uſe of the blood, that it is a ſtimulus to excite the action of the heart and arteries, ſeems clear; firſt, becauſe theſe organs are evidently ſuſceptible of the action of ſtimuli, as they are abundantly ſupplied with the muſcular and medullary fibre; and ſecondly, becauſe the uſual effect of ſtimuli is produced upon the heart and arteries, viz. they are excited to action, and we perceive no agent immediately operating upon them, except the blood. We readily admit, that the nervous ſtimuli have alſo a conſiderable influence on the muſcular fibre of theſe parts, becauſe it is well known that the ſyſtole and diaſtole of the heart become more or leſs frequent, in a given period, in conſequence of various paſſions of the mind. In theſe caſes the mental energy operates on the muſcular fibre of the ſanguiferous ſyſtem, through the medium of the nervous ſtimuli. It has been alſo alledged, that the muſcular fibre of the heart may be ſubjected to the determination of the will, ſo as to become in ſome degree a voluntary muſcle. This in particular has been aſſerted by Fontana, as a power which he himſelf poſſeſſes. Whatever may be in this, it appears that the action of the heart and arteries is effected by the joint operation of the nervous ſtimuli and that of the blood. With the latter alone we are at preſent concerned.

Variations may take place in the action of the heart and arteries, from two cauſes. Firſt, a derangement in the organization, by which the ſuſceptibility in the animal fibre for the action of ſtimuli is in too great a degree increaſed or diminiſhed. Of the former we have evident examples, in many caſes of diſeaſe, in which we obſerve an increaſed action in the ſanguiferous ſyſtem. We cannot perhaps, in any of theſe caſes, point out the nature of the change which has taken place in the organization; but in every inſtance it is attended with univerſal debility in the body. Of the latter we have examples in many caſes of diminiſhed action in the heart and arteries, and in ſome inſtances we can clearly point out the nature of that change which has taken place in the organization, and by which it has become leſs ſuſceptible of the action of ſtimuli than is neceſſary for the healthful ſtate. The oſſifications which frequently take place in old age in the valves of the heart, and in the large blood-veſſels as they enter the heart, are ſtriking examples of this kind. In theſe caſes the proper matter of the animal fibre has in the uſual courſe been carried off, and its place ſupplied by oſſeous matter, a ſubſtance nearly unſuſceptible of the action of ſtimuli. Whenever this alteration takes place to a certain extent, the circulation of the blood is prevented, and the animal functions muſt entirely ceaſe. Thoſe inſtances in which the muſcular and medullary fibre, the cellular ſubſtance, &c. are changed into bony matter, furniſh an additional proof, that no material change takes place in the ſyſtem without the organization having undergone ſome alteration.

Secondly, Variations in the action of the heart and arteries may be cauſed by the ſtate of the blood. That this fluid may be ſubject to material alterations with reſpect to its qualities, cannot be denied; and from hence conſiderable varieties muſt follow in its ſtimulant power. In particular, it may be ſuppoſed, that very different proportions, of the ſaline ſubſtances which are uniformly found in the blood, may exiſt in it at various periods; and hence its qualities as a ſtimulant may be increaſed or diminiſhed. But theſe variations in the conſtituents of the circulating fluids, as we have already obſerved, have been ſo little attended to, that it is impoſſible to ſpeak of them with any degree of certainty.

It does not ſeem poſſible to aſſign the cauſe of the ſtimulating quality of the blood. Perhaps we ought to content ourſelves with obſerving, that in the healthful ſtate the blood is a mixture exactly fitted by nature to ſtimulate the organization of the ſanguiferous ſyſtem. The blood is preſerved in a proper ſtate to effect this purpoſe, by the ſupply of new matter which it receives from the aliment, and by the change which takes place upon it in the proceſs of reſpiration. That a ſupply of new matter from the aliment is neceſſary to preſerve the circulating fluids in the healthful ſtate, is too obvious to need proof: And that the proceſs of reſpiration is equally neceſſary, is evident, becauſe the abſtraction of reſpirable air for a ſhort period cauſes death. In this laſt caſe, we have ſo ſtriking an example of the blood in a ſhort ſpace undergoing ſome change, by which it is rendered incapable of ſtimulating the ſanguiferous ſyſtem, that it may not be improper to add a few obſervations upon the ſubject.

We have already obſerved, that the effects which appear to be produced in reſpiration are, firſt, The ſeparation of a quantity of carbonaceous matter from the blood; ſecondly, The evolution of heat; and thirdly, A change in the colour and qualities of the blood during its paſſage through the lungs. But can we ſuppoſe that the mere retention of a ſmall quantity of carbonaceous matter in the ſyſtem, or the diminution of ſenſible heat in the animal body, can be the immediate cauſe of ſudden death during the abſtraction of oxygene? It muſt, however, be remarked, that the change which takes place in the blood, by which it is rendered a proper ſtimulus to the heart and arteries, is certainly in part effected by the abſtraction of carbonaceous matter; and probably that change is alſo in a great meaſure owing to the continued evolution of heat during reſpiration. The ſenſible heat of the ſyſtem in general during the abſtraction of oxygene for ſuch a period as will cauſe death, is not ſo far diminiſhed as to produce any poſſible inconvenience. Nay, in ſome caſes, as in ſuffocation by the carbonic acid gas, it appears that the ſenſible heat of the body is rather increaſed. But, according to the experiments of Dr Crawford, it appears, that the relative capacities of the venous and arterial blood for receiving heat are as twenty to twenty-three. By the alteration then which takes place on the blood during reſpiration, the arterial blood acquires this increaſed capacity. Now, it is a known law of heat, that if two bodies of different capacities, and at different temperatures, are brought in contact, that body, the abſolute heat of which is greateſt, will raiſe or diminiſh the temperature of the body which has the leaſt capacity, much more than the latter can alter the temperature of the former; and this increaſe or diminution will be in the direct ratio of their capacities. Now the blood, during its paſſage through the lungs, not only acquires an increaſed capacity, or has its abſolute heat augmented, but, by the evolution of heat in the lungs, its temperature or ſenſible heat is alſo increaſed; and conſequently, on being applied to the heart, it muſt give out a much greater quantity of heat than it could have done before it had undergone the change of which we are ſpeaking. It muſt further be obſerved, that the heat thus communicated to the muſcular fibre of the heart by the blood returned from the lungs, is not merely in proportion to the reſpective temperatures or ſenſible heat of the blood and muſcular fibre, but alſo to the enlarged capacity or abſolute heat of the blood. We might proceed to illuſtrate this ſubject, by employing numbers to denote the reſpective temperatures, and relative capacities for heat, of the muſcular fibre, and the venous and arterial blood; but experiments are yet wanting to enable us to employ the numbers which really expreſs the capacities, and perhaps alſo the reſpective temperatures. I ſhall therefore content myſelf at preſent with ſuggeſting, that there is the higheſt degree of probability to ſuppoſe, that the qualities which the blood acquires during its tranſmiſſion through the lungs, by which it is fitted to be a proper ſtimulus to the heart and arteries, depends on the abſtraction of carbonaceous matter, and the quantity of heat which it becomes able to give out to a ſubſtance of a lower temperature. And laſtly, As we have obſerved that the immediate cauſe of death, when produced by the abſtraction of oxygene, is, that the blood is no longer a proper ſtimulus to excite the action of the heart and arteries; now, if what we have here ſuggeſted is founded on facts, it will follow, that the beneficial effects derived to the animal ſyſtem muſt be confined to the conſumption and carrying off the carbonaceous matter and the evolution of heat; conſequently, although the oxygenous gas may itſelf ſtimulate the lungs, yet it is not to be conſidered as producing this effect on the ſyſtem at large, but that it is the chief ſource by which the ſyſtem is ſupplied with the ſtimulus of heat.

The ſexual intercourſe is the ſecond internal power which we have mentioned. Though not eſſential to animal life, it is abſolutely neceſſary for the continuation of the ſpecies, and it is a powerful ſtimulant to the ſyſtem. The mental energy in this caſe ſeems to co-operate with a material ſtimulus. Excited by the ideas of beauty, real or ſuppoſed, in a particular object, and ſtimulated by a liquor ſecreted from the blood, and lodged in the veſiculæ ſeminales, or perhaps exiſting in the blood *, man, generally ſpeaking, during a certain period of life, feels himſelf under the influence of an irreſiſtible impulſe. The exhauſtion which follows the action of this power, clearly illuſtrates our general doctrine, with reſpect to the operation of ſtimuli. When the paſſion is too freely indulged, it is a well-known cauſe of univerſal debility.

The third internal power which operates upon the body, is muſcular motion. This appears to be abſolutely eſſential to the continuance of animal life. If this ſti-

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* The late Mr John Hunter, in oppoſition, I believe, to the opinion of moſt anatomiſts, has denied the previous ſecretion of the ſemen.

mulus does not act in a ſufficient degree, i. e. if only partially abſtracted, diſeaſe certainly follows: which, though perhaps ſlow in its progreſs, infallibly ſhortens the period of human exiſtence. Examples of this kind fall daily under our obſervation, in people whoſe lives are ſedentary, whether from neceſſity or habitual indolence. The contrary extreme, or exceſſive labour, produces a ſimilar effect. In both caſes, a debilitated ſtate of the organization is induced.

It is not our intention to attempt an explanation of the cauſe of muſcular motion, any farther than, as we have already obſerved, that muſcular motion obviouſly depends on the nervous ſtimuli: for although contractions can be produced by the action of mechanical or chemical ſtimuli, in the muſcular fibre, both in the living ſtate, and for ſome time after the apparent death of the animal, and which contractile power is not poſſeſſed by the medullary fibre; yet, as we have already hinted, all the motions of the body in the living ſtate, both voluntary and involuntary, depend on the operation of the nerves, which, by their univerſal diſtribution throughout all the muſcles, unite the whole into an indiviſible organized ſyſtem, of which the ſenſorium commune is the central point.

We would not wiſh to decry the labours of thoſe who have endeavoured to aſcertain the cauſe of muſcular motion; yet it ought to be remarked, that every attempt of the kind has hitherto been unſucceſsful. The ſuppoſed nervous fluid, —an inviſible æther, — and electricity, have all been in vain employed. Nor does the very ſingular and curious influence recently diſcovered by Galvani ſeem to throw any further light upon the ſubject *. In the preſent ſtate of our knowledge

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* The following quotation is given merely as an example to what extent ingenious men can indulge themſelves in fanciful hypotheſes: "Does not muſcular contraction, " or intumeſcence, really depend upon the combination of " oxygene with hydrogene and azote," (ſeparately and combined in various proportions), " in conſequence of a ſort

ledge at leaſt, we muſt reſt ſatisfied with the ſimple fact, that ſuch a power of motion is poſſeſſed by organized matter; and that this motion is produced by the operation of ſtimuli. It will follow then, that the proper exerciſe of this motion depends upon a certain ſtate of the organization, and the operation of the natural agents in due proportion. If thoſe eſſential ſtimuli, heat, air, and aliment, are in any degree abſtracted, a proportionate degree of weakneſs will be produced in the

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" ſort of exploſion produced by the nervous electricity?
" According to this hypotheſis, animal motion, at leaſt
" that of animals analogous to man, would be produced
" by a very beautiful pneumatic machinery; and our
" nervous and muſcular ſyſtems may be conſidered as a
" ſort of ſteam engine. This hypotheſis, though not per-
" haps at this moment capable of ſtrict proof, is extremely
" probable, ſince it is countenanced by every obſervation
" and experiment yet made on the ſubject.' Vid. Obſervations on the nature and cure of Calculus, &c. by Dr Beddoes, page 258. Can any one ſeriouſly believe that an *exploſion* of oxygene and hydrogene takes place in every inſtance of muſcular contraction? At the beginning of the preſent century, the human frame was ſuppoſed to be a hydraulic machine. We are now changed into ſteam-engines, or perhaps into pneumato-chemical apparatus.

the organization, and the power of motion is conſiderably diminiſhed. It is equally true, that the abſtraction of theſe ſtimuli to a certain degree will produce the moſt violent ſpaſms and convulſions, i. e. morbid muſcular motion. Theſe irregular motions of the muſcular fibre, evidently depend on a debilitated ſtate of the organization, produced, in this caſe, by the abſtraction of ſtimuli. A well known fact, which is every day ſeen in the ſhambles, will clearly illuſtrate this point. When an animal is put to death by the abſtraction of blood, its life terminates in ſtrong convulſions. Here the irregular motion of the muſcular fibre, is a conſequence of that debility which is induced by abſtracting the uſual ſtimulus of the blood.

But as the power of motion in the muſcular fibre is diminiſhed in proportion to the abſtraction of the uſual ſtimuli, and is totally deſtroyed if theſe ſtimuli entirely ceaſe to act upon the body; ſo alſo that power of motion may be diminiſhed and deſtroyed, by the ſame ſtimuli acting with too great force, or by the more powerful artificial ſtimuli, as alcohol, opium, &c. when operating to a certain extent. In this caſe debility is induced as well as in the former. The body in the firſt inſtance may be more highly excited, and the animal fibre may acquire a greater degree of vigour by the exceſſive action of ſtimuli; but in the ultimate effects we can obſerve no material difference in the debilitated ſtate of the organization produced by the exceſſive action or abſtraction of ſtimuli.

The principal point, however, to which we are here to attend, is, that the muſcular motion itſelf, by whatever means produced, is a ſtimulus to the ſyſtem in general. The operation of this power is neceſſary to effect, in a due proportion, all the ſecretions and excretions of the body. Hence muſcular motion is eſſential to the healthful ſtate, and, like every other ſtimulus, its exceſſive action is well known to be injurious. Whether any unknown change takes place on the animal fibre by a too much increaſed or diminiſhed muſcular motion, it is impoſſible to determine. But it is ſufficiently obvious, that a material alteration muſt take place in the organization, from too great an increaſe or diminution in the ſecretions and excretions which neceſſarily follow an extreme or diminiſhed muſcular action. By the firſt, the body is deprived too rapidly of matter; and by the ſecond, thoſe ſubſtances which have performed their deſtined uſe, and which ought to be carried off, are detained in the ſyſtem.

The fourth and laſt of the internal powers which operate upon the body, is the mental energy. In every action of life the influence of mind upon the body is perceptible, and the moſt material alterations are produced on the organization by the operation of the more violent mental paſſions.

It is not our buſineſs to inſtitute an inquiry relative to the nature either of the mind itſelf, or of that intimate connection which ſubſiſts between it and the body. That the greater part of our mental perceptions are derived from impreſſions made by external objects, and conveyed to the mind by the organs of ſenſation, is ſufficiently evident; and that the mind reacts upon the bodily organization is equally obvious. The continued exertion of the mental energy is neceſſary to produce the action of all the voluntary muſcles. Hence it ſeems clear, that the mental energy operates as an exciting power or ſtimulus to the bodily organization.

That exerciſe of the mental power which is termed thinking, is evidently ſtimulant to the material organization. The exerciſe of this function will protract the waking ſtate, even when the body is much exhauſted by labour. Thinking, however, like every other ſtimulus, produces that change on the organization which renders the body leſs ſuſceptible of the action of ſtimuli. The univerſal laſſitude which follows ſevere ſtudy, and which has been experienced by every perſon capable of intenſe thinking, ſufficiently exemplifies this obſervation. But the continued exertion of this function will, like every other ſtimulant power, produce that degree of debility in the animal body, by which it becomes ſo much ſuſceptible of the action of the various agents as to conſtitute the morbid ſtate. Hence morbid watchfulneſs may be produced by intenſe thinking. The faculty of thinking appears then to be capable of producing very material alterations in the ſtate of the animal fibre. When exerciſed in a moderate degree, it gives energy to the ſyſtem; but if its action is too much increaſed, it will produce all the various ſtages of debility, and will not only accelerate the deſtruction of the ſyſtem, but, perhaps, if acting in a very high degree, may produce ſudden death.

But it is in the more powerful effects upon the bodily organization produced by the ſtronger paſſions, that we can diſcern the extraordinary influence of the mental energy upon the body, and are, in ſome degree, enabled to aſcertain the nature of its operation. The paſſions are naturally divided into two kinds: They have been termed the exciting and the ſedative paſſions. Of the firſt kind, are, confidence, hope, joy, love, anger, and hatred. Fear, ſorrow, grief, and deſpair, are of the ſecond kind. It will be generally admitted, that the firſt claſs ſtimulate, or produce a temporary energy in the ſyſtem; and it is certain, that their continued action exhauſts or debilitates the body. If operating in an exceſſive degree, they are capable of ſo far deranging the organization as to produce death. The effects of exceſſive joy or anger in this reſpect, are too well known to need exemplification.

The depreſſing paſſions, on the other hand, immediately debilitate the organization. The effects of fear or grief, if ariſing to any conſiderable degree upon the human body, are, loſs of appetite, indigeſtion, and other ſymptoms of dyſpepſia, diarrhœa, and that degree of debility which produces the morbid watchful ſtate. The ſyſtem alſo becomes more ſuſceptible of the action of deleterious powers, as the contagion of typhus, &c. The ſame total derangement of the organization follows the exceſſive operation of theſe paſſions, as well as the former claſs. Thus exceſſive fear or grief has often produced death.

It has been alledged, that the depreſſing paſſions are only a diminution of the exciting paſſions, not emotions of an oppoſite nature *; That they are therefore to be conſidered as weak ſtimuli, and that their operation upon the body is the ſame as the abſtraction of the neceſſary ſtimuli. This opinion is inadmiſſible; Firſt, Becauſe, as we have formerly obſerved, no power can be conſidered as ſtimulant, unleſs, when operating in a certain degree, it has the effect of producing energy in the ſyſtem. But fear or grief, operating in any degree, produce debility.

Secondly,

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* Vid. Element. Med. Brun.

Secondly, It is manifeſtly abſurd to ſuppoſe, that grief is merely the abſtraction of joy, or fear of confidence. We cannot avoid perceiving, that the depreſſing paſſions are not mere abſtractions of ſtimulant agents, but are rather powers which operate with conſiderable force, directly inducing debility in the ſyſtem. This claſs of paſſions, therefore, muſt be conſidered as ſedative powers; and the conviction that they are ſuch, naturally leads us to conclude, that there are other ſubſtances in nature which alſo produce a directly ſedative effect upon the body. Such, perhaps, is the marſh miaſmata, and the contagion of typhus.

In the proſecution of this Eſſay we have ſeen, that the human body, though formed of matter under various modifications, poſſeſſes a ſtriking ſimilarity in the organization of all its parts. Through the union of theſe parts by the univerſal diſtribution of the nerves, a complete and indiviſible ſyſtem is formed. And ſuch is the unity of the body, that no power can poſſibly operate upon any part of it, without, in a greater or leſſer degree, affecting the whole.

The body, thus formed, appears to be ſuſceptible of impreſſions from a great variety of agents. A particular ſet of theſe, which we have ſtyled the natural or healthful agents, by their operation upon the body, produce the phenomena of life. This ſuſceptibility of impreſſions, which we obſerve in the body, we are conſtrained to aſcribe to its peculiar organization. Every attempt hitherto made to aſcertain the cauſe of this ſuſceptibility, has failed. The utmoſt extent of our knowledge upon this ſubject, appears to be, that life, and all its various phenomena, are produced by the action of the healthful agents upon matter peculiarly organized.

The continuance of life, and the preſervation of the healthful ſtate, appear to depend upon the natural agents acting in a degree proportioned to the ſtate of the organized matter. If theſe agents are partially withdrawn, a debilitated ſtate of the organization is produced, in proportion to the extent and period in which theſe healthful powers are abſtracted. In all theſe caſes we ſee a progreſſive debility taking place, which finally terminates in death. The ſame effect is produced by the total abſtraction, for a very ſhort period, of all or any of thoſe agents, the operation of which is eſſential to the continuance of life, ſuch as heat, air, and aliment.

The ſame healthful ſtimuli, acting in too great a proportion, produce a derangement of the organization, which is alſo marked by debility, and which will alſo terminate in death. But this is always preceded by an apparently increaſed vigour in the ſyſtem, unleſs the action of the ſtimuli is in an exceſſive degree. In this laſt inſtance, i. e. when the ſtimuli act in an exceſſive degree, death is ſpeedily, and in ſome caſes inſtantaneouſly, induced.

The debilitated ſtate of the organization, whether produced by the abſtraction or exceſſive action of the natural agents, or of the artificial ſtimuli, differs not in its nature. Though produced by theſe oppoſite cauſes, it can only be removed by the ſame means, viz. employing the healthful and artificial agents in a due proportion. The diſtinction, therefore, between direct and indirect debility, ſeems not to be founded in nature.

When, by the due action of the natural agents, the body has acquired its higheſt ſtate of vigour, i. e. during the period of manhood, the organization becomes leſs ſuſceptible of the action of many ſtimuli. This ariſes merely from the vigorous ſtate of the animal fibre. Habit may alſo, for a ſhort period, inure the body to the action of certain ſtimuli, ſo as to render it neceſſary to employ a larger proportion, in order that the uſual effect may be produced. But the animal ſyſtem cannot be habituated to the exceſſive action of any ſtimuli. If their operation is increaſed in any degree, beyond what is abſolutely required to preſerve the healthful ſtate, debility muſt be induced. In old age, man becomes more ſuſceptible of the action of powerful ſtimuli than in middle life. Hence the ſuppoſition, that in advanced life an increaſed proportion of the artificial ſtimuli becomes neceſſary, appears to be without foundation.

During the progreſs of life, we obſerve various modifications taking place in the animal fibre, by the operation of the healthful agents. From infancy to manhood the waſte of the ſyſtem is repaired,—the animal fibre is recruited,—the matter of the body is increaſed,—and a firm vigorous organization is produced, by the operation of the natural agents, particularly aliment. From manhood to old age another change progreſſively takes place. The animal fibre becomes daily leſs ſuſceptible of receiving new matter, till at length it is ſo far deranged that it cannot derive nutrition from the aliment. The action of the ſame powers which, from infancy to manhood, had increaſed the vigour of the bodily organization, during the ſucceeding period produces decay, and their continued operation finally exhauſts the ſyſtem, and iſſues in death.

From the ſubjects on which we have treated, many important deductions might be drawn relative to medical practice; but this would lead us beyond the bounds we have preſcribed. It may, however, be remarked, that the indiviſibility of the body ſeems to deſerve the moſt particular attention in the cure of diſeaſes. It is alone, by attending to this fact, that we can properly diſtinguiſh between general and local diſeaſes. It may be ſuſpected, that in many caſes local remedies are employed and depended on when the complaint is truly general, and can only be removed by producing a healthy ſtate in the organization of the whole ſyſtem.

That much more is to be expected in the cure of diſeaſes from diet and other regimen, than from medicine, is generally admitted. It cannot, however, be denied, that this maxim is not ſufficiently attended to in the practice of medicine: From a due application of the healthful agents the moſt important changes may be produced in the animal body. To the operation of theſe agents alone can we look for the cure of all diſeaſes of debility, and which include the greater part, if not the whole liſt of maladies to which human nature is ſubject. In no caſe of general diſeaſe, and there are few others, can a cure be expected from medicine alone, without a due attention to the diet and other regimen; but there are many caſes in which the latter may remove diſeaſe without aſſiſtance from the former.

FINIS.